

EUCALYPT - RAINFOREST RELATIONSHIPS

AND THE

REGENERATION OF THE EUCALYPTS

BY

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**Submitted in fulfilment of the requirements
for the Degree of**

DOCTOR OF PHILOSOPHY

UNIVERSITY OF TASMANIA

HOBART

JUNE 1958

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ACKNOWLEDGEMENTS

The work reported in this Thesis was carried out under a Fellowship provided by Australian Newsprint Mills Limited through the Forestry and Timber Bureau, Canberra. The Tasmanian Forestry Commission generously granted me three years leave of absence.

The Fellowship was under the general administration of a committee consisting of

Professor H.N.Barber, Professor of Botany,
University of Tasmania.

Mr.A.H.Crane, Chief Commissioner, Forestry
Commission, Tasmania.

Dr.M.R.Jacobs, Principal, Australian Forestry
School, Canberra.

Mr.S.L.Kessell, Managing Director, Australian
Newsprint Mills.

Mr.G.J.Rodger, Director-General, Forestry and
Timber Bureau. Chairman.

The immediate work under the Fellowship was supervised by a sub-committee consisting of Professor Barber and Dr.Jacobs. I owe much to their constructive criticism and advice.

My thanks are due to Mr.Kessell for the personal considerations I received far beyond the nominal terms of the Fellowship. Mr.D.T.Kitchener, the Company's Logging Superintendent, did a great deal to relieve

the burden of field work done under difficult conditions.

Apart from Professor Barber's personal interest and guidance, members of his staff assisted in many ways. Dr.W.M.Curtis checked the identification of plants, Mr.W.D.Jackson provided helpful discussion on the ecological background and Dr.D.M.Paton and Mr.C.J.Quinn allowed me to use Figs. 4.5(b) and 1.12 respectively.

Mr.T.S.McMahon, Head of the Photographic Section, University of Tasmania, took the photographs reproduced in Figs. 1.5, 1.6, 1.7, 1.8, 1.10, 1.13, 1.14, 1.16(b), 2.2, 2.3, 3.3, 4.4(b), 4.5(a), 4.6, 4.7, 4.8(b), 4.9, 4.10(b), 5.1, 5.2, 5.3 and 5.4.

PART ONE

THE
ECOLOGICAL BACKGROUND.
FOREST SUCCESSION
IN THE
FLORENTINE VALLEY
TASMANIA

THE ECOLOGICAL BACKGROUND-FOREST SUCCESSION IN THE
FLORENTINE VALLEY, TASMANIA.

SUMMARY.

The topography, geology, climate and soils of the middle Florentine (lat. $42^{\circ}30'S$, long. $146^{\circ}30'E$) are described. The vegetation consists of temperate rainforest, mixed forest (eucalypts with an understory of rainforest species), eucalypt forest and treeless areas.

Except perhaps on the poorest soils the climax is temperate rainforest and should the site be undisturbed by man (fire or axe) the climax condition is reached with the death, from old age, of the current generation of eucalypts which germinated at the last disturbance of the site.

The large areas of mixed forest date from past widespread fires. The rainforest species regenerate immediately after fire i.e. at the same time as the eucalypts, and do not have to invade from the edge of the burnt area. However, should fires occur several times per century the rainforest species will be drastically reduced or even eliminated.

The mixed forest is a fire-climax occupying a broad zone between the eucalypt forests of areas of lower rainfall and the rainforest of areas of higher rainfall and lower fire frequency. In the absence of fire the areas now occupied by mixed forest would carry rainforest and the ecotone between rainforest and eucalypt forest would probably be very steep and along the boundaries of poor soil.

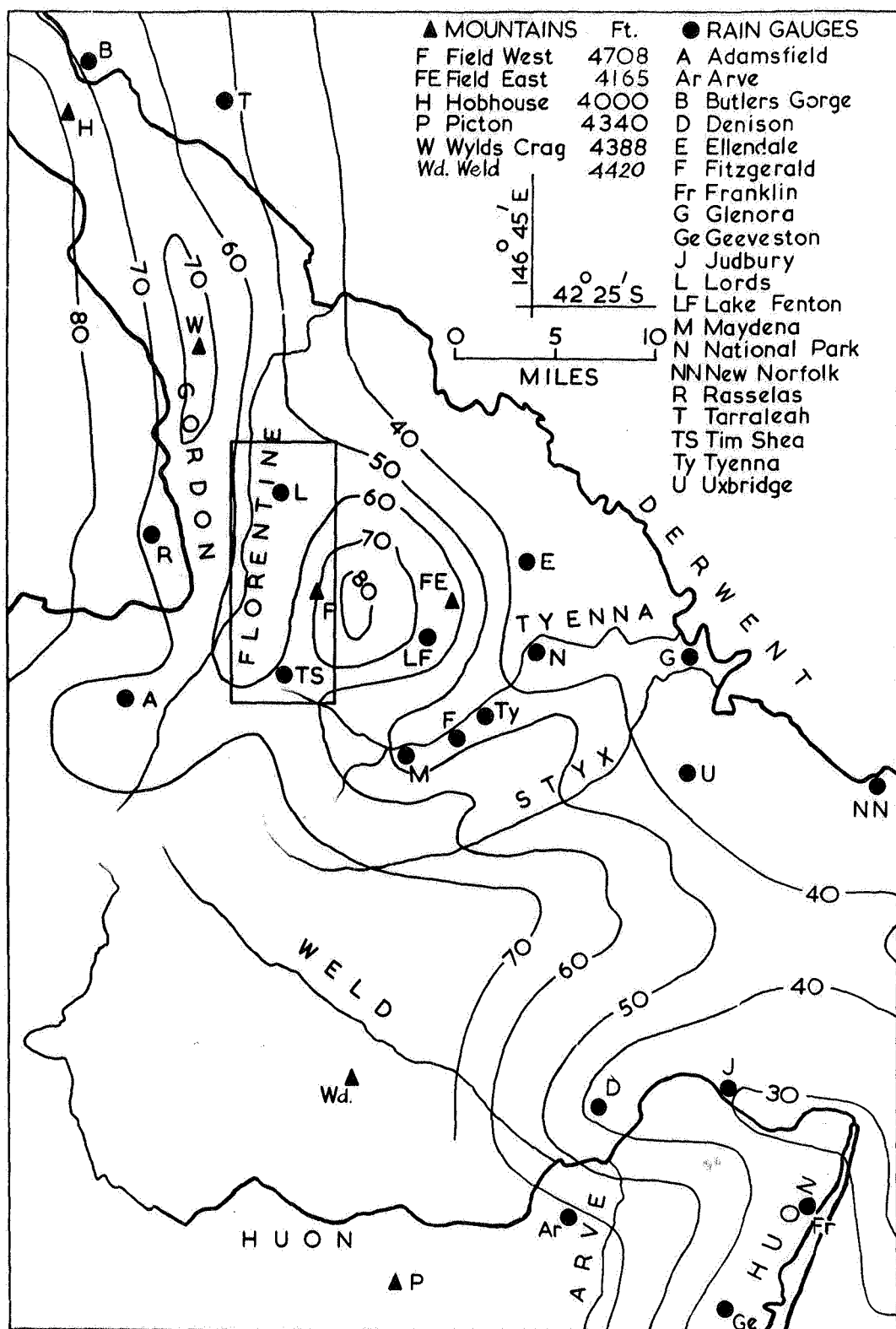


Fig. 1.1 Location of study area in Florentine Valley and annual average rainfall (ins.).

I. TOPOGRAPHY AND GEOLOGY

The Florentine Valley (latitude $42^{\circ} 30' S$, longitude $146^{\circ} 30' E$) is approximately 48 miles W.N.W. from Hobart, the river flowing from the south to join the middle course of the Derwent. This paper deals particularly with 12 miles of the middle Florentine from Tim Shea to Dawson's Road. (Figs. 1.1 and 1.2)

In this region the valley is broad and flat (Figs. 1.2 and 1.3), the river meandering along the western side of the valley floor which falls at a rate of about 1 in 250. By contrast, in the last six miles of its course to the Derwent River, the Florentine falls 525 ft. (1 in 60).

Dominating the valley, is a group of mountains rising steeply on the eastern side. From north to south the main points on this range are:- Misery (2500-3000 ft.), Lord (3900 ft.), Field West (4720 ft.), Florentine (4100 ft) and Wherretts (3300 ft.).

To the west are the moderately steep slopes of the Tiger Range (2000-2500 ft.) - the watershed between the Florentine and Gordon. Northwards this continues as the Gordon Range which culminates in Wyld's Craig (4388 ft.).

THE GEOLOGY of the area has been described as follows by Banks (1957):-

"The Florentine Valley is the eastern limb of the syncline of which the Tiger and Gordon Ranges form the axis. At its southern end, at Tim Shea, there is exposed the core of an anticline which plunges northwards into the syncline. The core of this anticline consists of Owen Conglomerate which is overlain by Caroline Ck. Sandstone and Florentine Valley Mudstone.

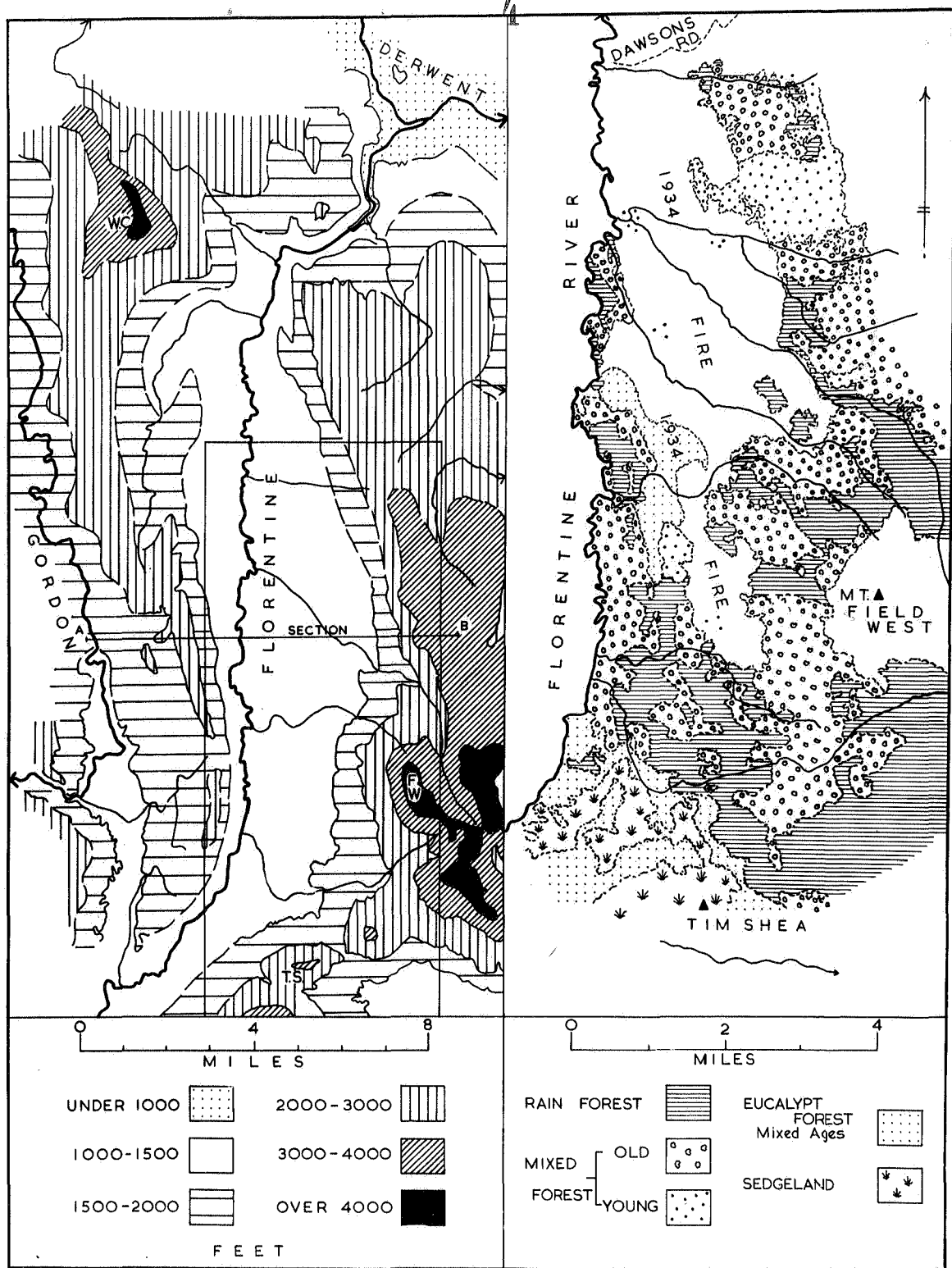


Fig.1.2 (a) Topography of Florentine Valley and surrounding districts. F.W- Mt. Field West, TC-(Mt.) Tim Shea, WC-Wylds Craig. (b) Distribution of forest types in middle Florentine Valley. Compiled from forest type map prepared by Tasmanian Forestry Commission.

"The Florentine Valley Mudstone is overlain by Gordon Limestone, which forms the greater part of the floor of the valley. The limestone is cavernous. It is overlain in the Tiger and Gordon Ranges by quartzites and siltstones of the Eldon Group.

"Along the eastern face of the valley the Gordon Limestone is unconformably overlain by almost horizontal beds of Permian sandstones and mudstones. These beds are intruded by sheets of dolerite which now cap the ridges such as the Misery Range, Lords, Field West, Wherrett's Look-out (Wyld's Craig is also capped with dolerite). A series of faults along the western edge of the dolerite are down-thrown to the north-east.

"In the valley itself the Gordon Limestone generally dips steeply westwards and in many places is overlain unconformably by unconsolidated, sub-horizontal beds of sand, gravel and cobbles. Near Lawrences Ck., these consist of fluvial gravels made up of rounded dolerite boulders. These may in part be fluvio-glacial as a small valley glacier occupied the head of the valley of the creek during part of the Pleistocene.

"Some beds of the Gordon Limestone have in places undergone selective silicification and these beds are now represented by ridges covered with white angular fragments of cherty material containing silicified corals." Throughout the floor of the valley and the lower slopes the surface drainage pattern is largely undifferentiated (subterranean drainage in limestone) and the surface is broken by local subsidences.

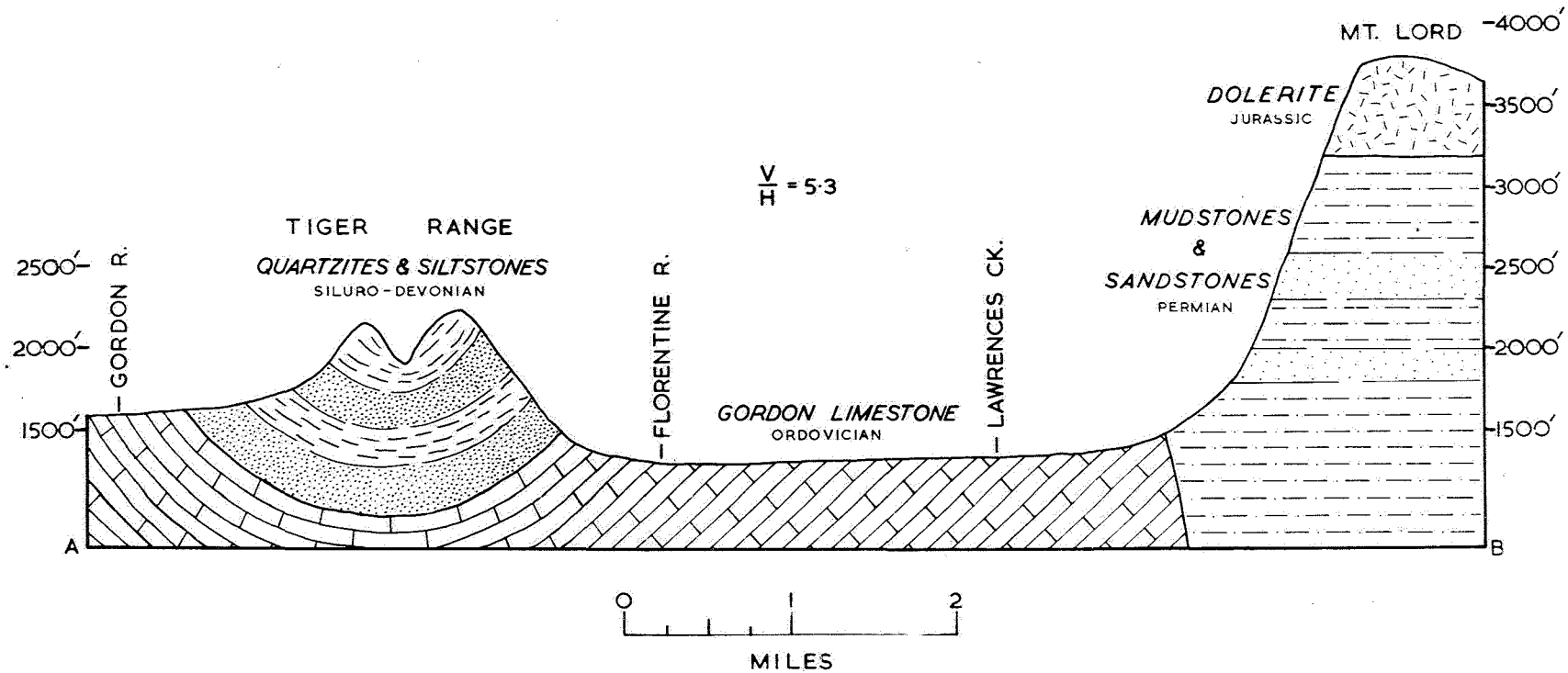


Fig. 1.3. GEOLOGICAL CROSS-SECTION on an E-W line from Gordon River to Mt. Lord. Location of section shown in Fig. 1.2 (a).

II. CLIMATE

1. GENERAL PATTERN.

Tasmania has a marine type of humid mesothermal climate (Cb of Trewartha - 1954). The general weather pattern is imposed by Southern Ocean depressions. During the winter Tasmania is characteristically within the westerly air-stream with high pressure cells passing to the north of Bass Strait. Heavy rain may fall ahead of or along the cold fronts associated with the depressions, and showery weather continues often for several days with the strong westerly to south-westerly air-stream behind the front. If a depression causes an outburst of Antarctic air, snow falls.

In summer little rain falls ahead of the cold front. Should the depression be intense enough, and have a trough extending into the Australian continent, hot, dry air of the Continental air-mass is brought in over the State. If forest fuels are already dry and these winds strong, any fires that occur will be severe (Gilbert 1949). Such winds do not often blow for more than 24 hours.

Only scanty climatic information is available from the Florentine Valley itself and most of the records for nearby stations are for short terms.

2. PRECIPITATION

The data in Table 1.1 indicate the monthly distribution of rainfall (for location of stations see Fig. 1.1).

TABLE 1.1 Mean monthly rainfall in points.

STATION:	MAYDENA	LAKE PENTON	TARRALEAH
NO. OF YEARS:	5	15	21
Jan.	350	386	369
Feb.	341	448	361
Mar.	299	425	283
Apr.	387	506	362
May	334	532	413
Jun.	383	573	360
Jul.	464	555	500
Aug.	477	600	629
Sep.	582	651	691
Oct.	485	596	442
Nov.	381	596	331
Dec	403	472	549
YEAR:	4886	6340	5290

Over three years (1955-57) the rainfall at Tim Shea averaged 59.97 ins. and at Lords 47.27 ins. for two years (1956-57). After considering data for long-term stations outside the Florentine (ratio of actual to mean catches for the years 1955, '56 and '57), the scanty information from the Florentine suggests that the mean annual rainfall at the southern end of the study area is 60-65 ins. and towards the northern end 50-55 ins.

In drawing the rainfall map (Fig. 1.1) some allowance has been made for the effect of topography and to some extent vegetation has been used as a guide.

The 80" isohyet on the Field Range is justified by topography and by a comparison of the vegetation of the Range with ^{that} near places such as the Cradle Valley, the Hartz-Adamsons-La Perouse range and the mountains near Lake St. Clair. Martin (1939) compared the development of the Austral-Montane shrubberies on several Tasmanian mountains and in particular referred to the relation between annual rainfall and the development of the dwarf endemic conifers. There are communities of Diselma archeri, Pherosphaera hookeriana, Athrotaxis cupressoides and Microcachrys tetragona on the Field West Range, which following Martin, suggests that the annual rainfall is at least 80".

The seasonal distribution of rainfall for nearby stations is shown in Table 1.2.

TABLE 1.2 Seasonal Distribution of Rainfall.

STATION	ELEV- ATION FT.	ANNUAL RAIN- FALL. PTS.	% OF ANNUAL RAINFALL			
			Jan-Mar.	Apr-Jun.	Jul-Sep.	Oct-Dec.
Maydena	870	4886	21	22	31	26
Lake Fenton	3450	6340	20	25	29	26
Tarraleah	2050	5290	19	22	34	25

The winter bias is not extreme and 20% of the annual rainfall occurs in the three summer months, January - March.

Snow is to be expected in all parts of the area each winter. On the floor of the valley snow rarely remains for more than 1-2 days. On the lee slopes (E-NE) of the

Field West Range snow drifts may persist into January. It would be unusual for snow to lie for more than a few weeks in the Eucalyptus gigantea forest below 3000'.

Fogs. Low level fogs are very common during the winter months and often do not disperse from the flats until mid-day.

3. TEMPERATURE.

Short-term records are available from Maydena and Tarraleah - Tables 1.3 and 1.4. Maydena is within the Eucalyptus regnans forest belt but Tarraleah is at a higher elevation and in Eucalyptus gigantea forest. The figures for Tarraleah are indicative of temperatures just beyond the range of regnans.

TABLE 1.3 Monthly mean maximum and mean minimum screen temperatures

STATION	NO. OF YRS.	°F												YR.
		J	F	M	A	M	J	J	A	S	O	N	D	
MAY DENA	4	MEAN:												
		Max.	72	71	67	59	54	49	49	51	56	58	61	67
		Min.	46	47	43	42	38	35	33	35	36	38	41	44
TARRAL- EAH	x	MEAN;												
		Max.	65	68	64	58	52	46	46	49	53	57	61	65
		Min.	44	44	42	41	34	31	31	33	34	36	40	42

x Unofficial station; basis for means uncertain.

**TABLE 1.4 Absolute maximum and minimum screen
temperatures at Maydena. 1952-57**

MONTH:	J	F	M	A	M	J	J	A	S	O	N	D	Year
Maximum	91	90	87	76	68	66	58	64	72	71	86	92	92
Minimum	34	31	30	30	28	22	20	22	23	26	32	38	20

From the data of Table 1.4 it is clear that frosts may occur at Maydena in any month. In the Florentine frosts are usually widespread but only one uncertain case has been observed of frost-heave of young seedlings. Rime may form on the crowns of eucalypts, even when more than 200 feet high.

4. WIND

The general pattern of the westerlies of the southern hemisphere have been described by Trewartha (1954). One of their distinguishing characteristics is "spells" of weather i.e. at times, and especially during the winter, the wind blows with gale force, while upon other occasions mild breezes prevail. Moderate to strong winds (Beaufort scale 3-7; 8-38 m.p.h.) are most numerous with strong winds (B.Scale 8-12; 39-71 plus m.p.h.) more prevalent than weak winds (B.Scale 1-2; 1-7 m.p.h.). Calms are infrequent. The westerlies are more boisterous on the average than the Trades.

In the Florentine Valley winds are generally light from all quarters except N.W. - S.W. Precise

information is not available from nearby weather stations but some data for Hobart is representative except that the positions of Mt. Wellington and the Derwent estuary turn the W.-S.W. stream winds to N.W.

For the period 1930-1947 the annual wind-gust maxima were distributed as follows:-

<u>WIND SPEED M.P.H.</u>					
<u>51-55</u>	<u>56-60</u>	<u>61-65</u>	<u>66-70</u>	<u>71-75.....</u>	<u>86-90</u>
4	1	4	5	3	1

The lowest maximum was 54 M.P.H. in 1931, the highest 87 in 1946.

For the 34 year period (1922-56) the frequencies of the directions of the annual wind-gust maxima were: North 1, north-west 22, west 10, south 1.

Over the periods 1841-79 and 1882-1943 the mean number of days per month with gales were as follows:-

July:	less than 1
October:	2
All other months:	1

(A gale is said to occur when for any occasion of about 10 minutes the average wind is 39 m.p.h. or more). Gusts could be expected to reach a wind speed at least 50% above that for the mean of a 10 minute period.

III. SOILS.

The soils of the area have been described by Nicolls (1958) as follows:-

"The leaching potential of the climate is high so that soils, other than young ones, are highly leached.

"On the broad, limestone floor of the valley a deep, yellow podsollic soil has developed. The accumulation of soil is due to the fact that the limestone is very impure. The classical soils of limestone - Terra Rossas and Rendzinas - apparently do not occur in the Florentine, presumably because of the wet environment. pH varies from 5.3 to 5.7.

"The soils developed on the highly siliceous rocks on Tim Shea and on the low ridges of silicified limestones (see I Topography and Geology) are typical of those on similar parent materials elsewhere in Tasmania. They are sandy and gravelly, highly acid (pH 4.1 - 4.4) and have considerable accumulation of organic matter in the A and B horizons. The soils developed on the silicified limestone have yellow clay at a depth of several feet.

"There are large areas of young soils because of the presence of recent deposits. The two important ones are:-

(1) the Lawrence's Ck. fluvio-glacial deposits, which fan out on the floor of the valley. These deposits were probably laid down during the late Pleistocene.

(2) the mantle of solifluction debris which presumably dates from the concluding stages of the late Pleistocene glaciation. This type of material is common in central and eastern Tasmania above 2000 ft. but occasionally it may descend in ribbons to as low as 1000 ft. (Davies, 1958).

"On the fluvo-glacial deposits a brown loam has been developed which has an apparently uniform profile to a depth of 3-4 ft. and overlies dolerite gravels. Internal drainage is free. Over wide area the solifluction deposits overlie the Permian mudstones and sandstones (Fig. 1.3) and essentially consist of unsorted dolerite boulders of all sizes in an earthy matrix. There is little differentiation in the soil profile, apparently due to limited downward movement of iron and clay. The solifluction deposits are probably important in that they bring weathering dolerite on to the rather sterile Permian sediments."

Sedgeland, wet scrub or poor-quality eucalypt forest occur on the soils derived from siliceous rocks or silicified limestone. The other soils support a forest of good quality.

In unburnt forest there is an accumulation of organic matter at the base of large Nothofagus and Eucalyptus, to a depth of 1-2 ft. This material is in the form of a cone and within a few yards the layer may be less than an inch thick. Beneath Atherosperma the litter layer is virtually absent, even at the base of the trees.

IV. FOREST TYPES

1. NOMENCLATURE

(1) Taxonomic

As the latest complete Tasmanian Flora was compiled more than fifty years ago (Rodway 1903) the names used have been taken from several sources.

- (1) Gymnosperms and the Polypetales (of Bentham & Hooker) except Eucalyptus from Curtis (1956)
- (2) Eucalypts - Blakely (1934)
- (3) Ferns - Wakefield (1957)
- (4) Other Tasmanian plants - Rodway (1903)
- (5) For plants not covered above, the authors' names are given in an Appendix. As a general rule, eucalypts are referred to by their specific names only.

(ii) Ecological

The classification proposed by Beadle and Costin (1952) is used to the extent to which it is applicable. The eucalypt-rainforest mixtures would be called "wet sclerophyll forest" but in reality they do not conform to the definition of this type in several important respects e.g. the scattered eucalypts which occur above the understory of rainforest species do not have densely interlaced crowns. Accordingly this type is labelled "Mixed Forest". Jacobs (1936) has suggested that the tender naked buds make interlacing impossible. Eucalypt crowns never interlace in the way that many other trees do. For want of a better term, all stands of eucalypts, other than those with a well developed understory of rainforest species have been called "Eucalypt Forest". The term "sedgeland" (Jackson 1958) is used for the more or less treeless vegetation which is found on shallow acid

soils. It consists of a mixture of low shrubs of the families Myrtaceae, Epacridaceae and Proteaceae and sedge-like plants of the Cyperaceae and Restionaceae.

2. PRELIMINARY NOTE

Jackson (1958) has suggested that for S.E. Australia generally, rainfall requirements for the development of temperate rainforest are an annual fall of at least 50" with a minimum of 2" in each of the months of January, February and March. Other estimates of minimum annual rainfall for rainforest in Tasmania have been 50" by Curtis and Somerville (1949) and nearly 60" by Gilbert (1949). Fires have upset ecological succession in the region but it is apparent that at Maydena (49 ins) and Tarraleah (53 ins) a lowered fire-frequency would have allowed rainforest to have developed fairly generally.

In the central Florentine Valley the climax is temperate rainforest except on some very acid soils of low fertility where the climax would be eucalypt forest or sedgeland.

Fire has been the major factor preventing the general attainment of climax vegetation. On soils of moderate to high fertility the particular frequency of fires has determined the point reached in the succession towards the climax. Thus:

1. if an area remains unburnt for a single period of 350-400 years (life span of the main forest eucalypts) the climax condition is achieved;
2. if an area is burnt infrequently but with an interval between fires of less than 350 years, it remains under mixed forest. The forest is destroyed by each fire but the species present in the fully developed mixed forest regenerate immediately after the fire;

3. with a fire frequency of once or twice per century the mixed forest is replaced by eucalypt forest with an understory characterised by Pomaderris, Olearia and Acacia instead of climax rainforest species;
4. still more frequent fires, perhaps at ten to twenty year intervals, will not only prevent eucalypt forest progressing to mixed forest but will maintain obliqua and gigantea at the expense of the much more fire-sensitive regnans;
5. there is evidence that very frequent fires were responsible in part for the maintenance of savannah-like conditions in the middle Florentine until perhaps 100-200 years ago.

On the soils of low fertility much sedgeland would have progressed to wet scrub if not to low eucalypt forest but for frequent fires. These are possible because of the inflammable nature of the vegetation and have occurred because the open sedgelands were routes of travel of the aboriginals and later white man.

With all forest types, freedom from fire - which means progression towards the climax - leads to floristic simplification. The ultimate in simplification is temperate rainforest, a condition unlikely to be attained on very poor soils. As soils improve, two main changes take place:-

1. tree height increases
2. the floristics become simplified.

Neither aspect nor drainage are generally decisive in determining the distribution of forest types, although the development of sedgeland is favoured by impeded drainage on poor soils. Except on small flats along the Florentine River, drainage is good on the limestone floor of the valley.

Aspect has little direct influence in the distribution of the forest types. Rainforest and old mixed-forest cover most of the westerly and north-westerly slopes of the Field West Range from Field West to Tim Shea because the middle Florentine is protected from fires from the west and north-west by the Tiger and Gordon Ranges. The main source of past fires has been in the vicinity of Dawson's Road and further north.

Elevation sets limits to the distribution of species but not to vegetation types. Thus regnans is not found above 2000 ft. but mixed forest is common and dwarf rainforest is occasionally found to the limits of eucalypts at 4000-4200 ft.

3. FOREST TYPES

The following forest types will be considered:-

(A) Temperate Rainforest

This is an association of Nothofagus cunninghamii and Atherosperma moschata, in which other flowering plants are of rare occurrence except under special circumstances.

(B) Mixed Forest

The mixed forest consists of eucalypts with an understory of rainforest species. In old stands the understory is not essentially different in structure or floristics from that of pure rainforest. In any one stand the eucalypts are of the same age ("even-aged")

(C) Eucalypt Forest

(a) on soils of moderate to high fertility.

In these forests Nothofagus and Atherosperma play a minor role at present. The eucalypt forest will be dealt with as follows:-

- (i) areas effected by the 1934 or later fires
- (ii) areas which until recently carried savannah woodlands
- (iii) areas burnt probably 3-4 times in the last 200 years by fires of low intensity.

These are shown together as a blank area in Fig. 1.2(b) marked "1934 fire". Within this area there is great variation in the eucalypt stands.

(b) on soils of low fertility.

Fairly extensive areas of poor eucalypt forest occur on siliceous soils on Tim Shea, and in the floor of the valley on the low ridges formed from silicified bands of limestone. These are indicated in Fig. 1.2(b) as "Eucalypt forest - mixed ages".

(D) Non-forested

The principal non-forested areas are found on the slopes of Tim Shea on conglomerate and quartzite - shown as "sedgeland" in Fig. 1.2(b). In addition some very small treeless areas occur as remnants of the savannah of the middle Florentine.

A. TEMPERATE RAINFOREST(a) General

Temperate rainforest occupies large areas of the floor of the Florentine Valley to the north of Tim Shea and extends on to the steep slopes of the Field West Range from Wherrett's Look-out to Mt. Field West.

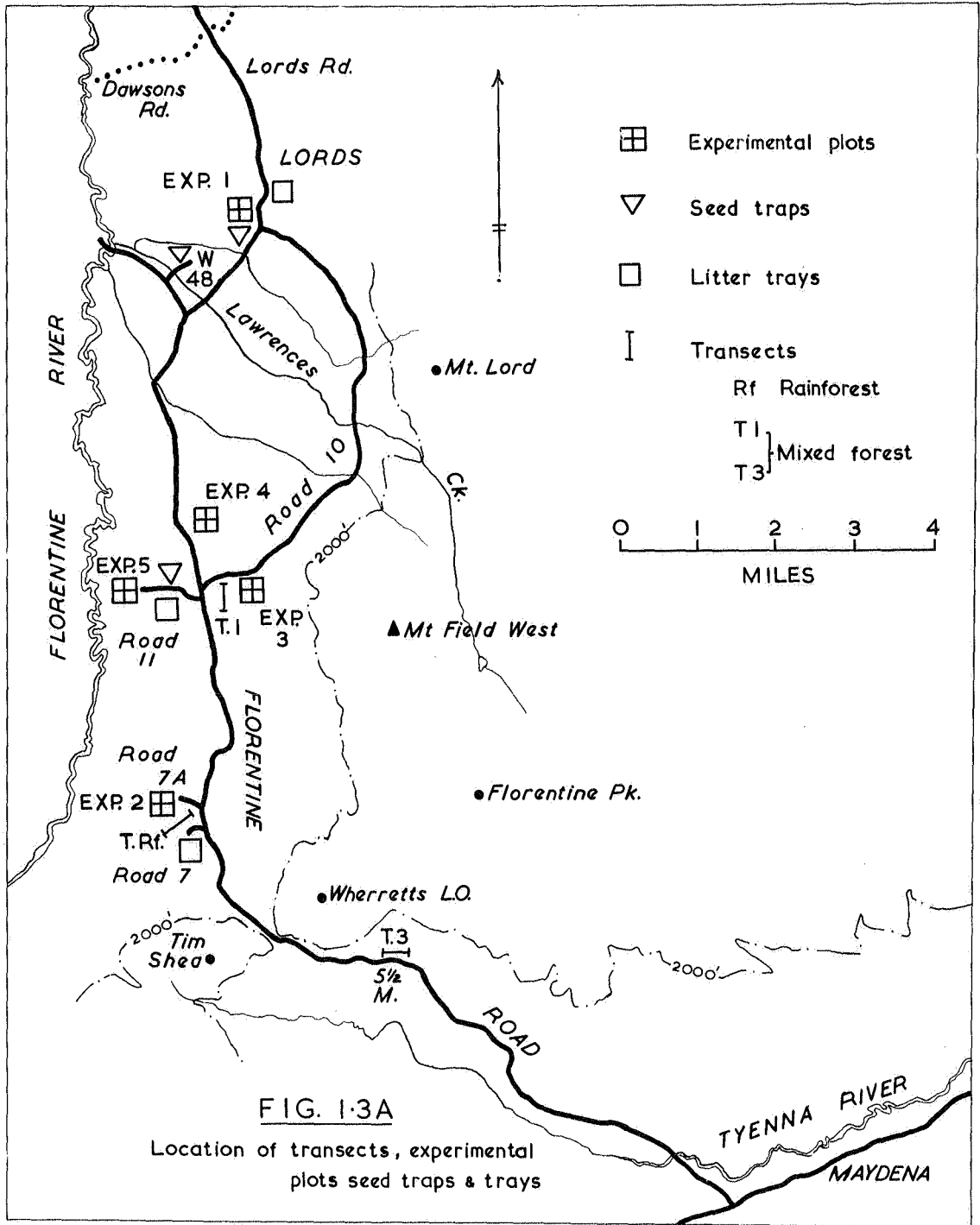
A feature of the forest, particularly on the lower slopes, is the small number of species present. Except for Nothofagus and Atherosperma, the counts of Spermatophytes are shown in Table 1.5 for five transects.

TABLE 1.5 Counts of Spermatophytes, other than
Nothofagus and Atherosperma on transects
in the Maydena district.

LOCATION	SIZE OF TRANSECT (FT.)	SPECIES	NO.
Road 7, Florentine	900 x 33	-	-
" "	250 x 50	-	-
Road 10, "	320 x 50	<u>Pittosporum bicolor</u>	1
5½ m. Florentine Rd.	345 x 50	" "	1
Styx Valley	660 x 33	<u>Olearia argophylla</u>	1

(For location of transects - except Styx - see Fig.1.3A)

In the above table the last three transects were in old mixed forests where the change to rainforest on the death of the eucalypts from old age, would not introduce new species. The transects may exaggerate the general position but it is clear that species other than Nothofagus and Atherosperma are not common. On good soils, species occasionally found are Pittosporum bicolor, Coprosma



billardieri, Clematis aristata and Aristotelia peduncularis. Where the canopy of Nothofagus and Atherosperma is broken as is usually the case on poor soils, Eucryphia lucida, Anodopetalum biglandulosum and Phyllocladus asplenifolius (trees) together with Anopterus glandulosus and Cenarrhene nitida (shrubs), may be locally frequent. An increase in the frequency of these species is fairly common on steep slopes at elevations above 1500-2000 ft. Olearia argophylla is not commonly found in rainforest or mixed forest. Lyonsia straminea has not been observed, the only liane found being an occasional Clematis.

(b) Description of Transect

The profile of a transect in rainforest is given in Fig.1.4. Although some trees on the 50 ft. wide transect could not be shown the only important omission is a dead Nothofagus 85 ft. high and 15 ft. in girth.

The upper stratum consists of Nothofagus which in spite of deep, dense crowns, have a general appearance of senility. Some have dead tops with Phymatodes diversifolium growing on the main limbs and there are two standing dead trees. The Nothofagus canopy is not complete (Fig. 1.5) for large gaps occur. It is in the gaps that Atherosperma reaches its maximum development. The dimensions of the five largest Nothofagus were:-

	<u>G.B.H.</u>	<u>Height</u>	<u>Crown Spread</u>	<u>Crown Depth</u>
Mean:	16.5	125	40	80
Maximum:	19	130	58	85

Measurements in feet.

Atherosperma has a total height of 80-100 ft. but does not develop a broad-topped crown as does Nothofagus. Also the crown is more open and persists to lower levels.

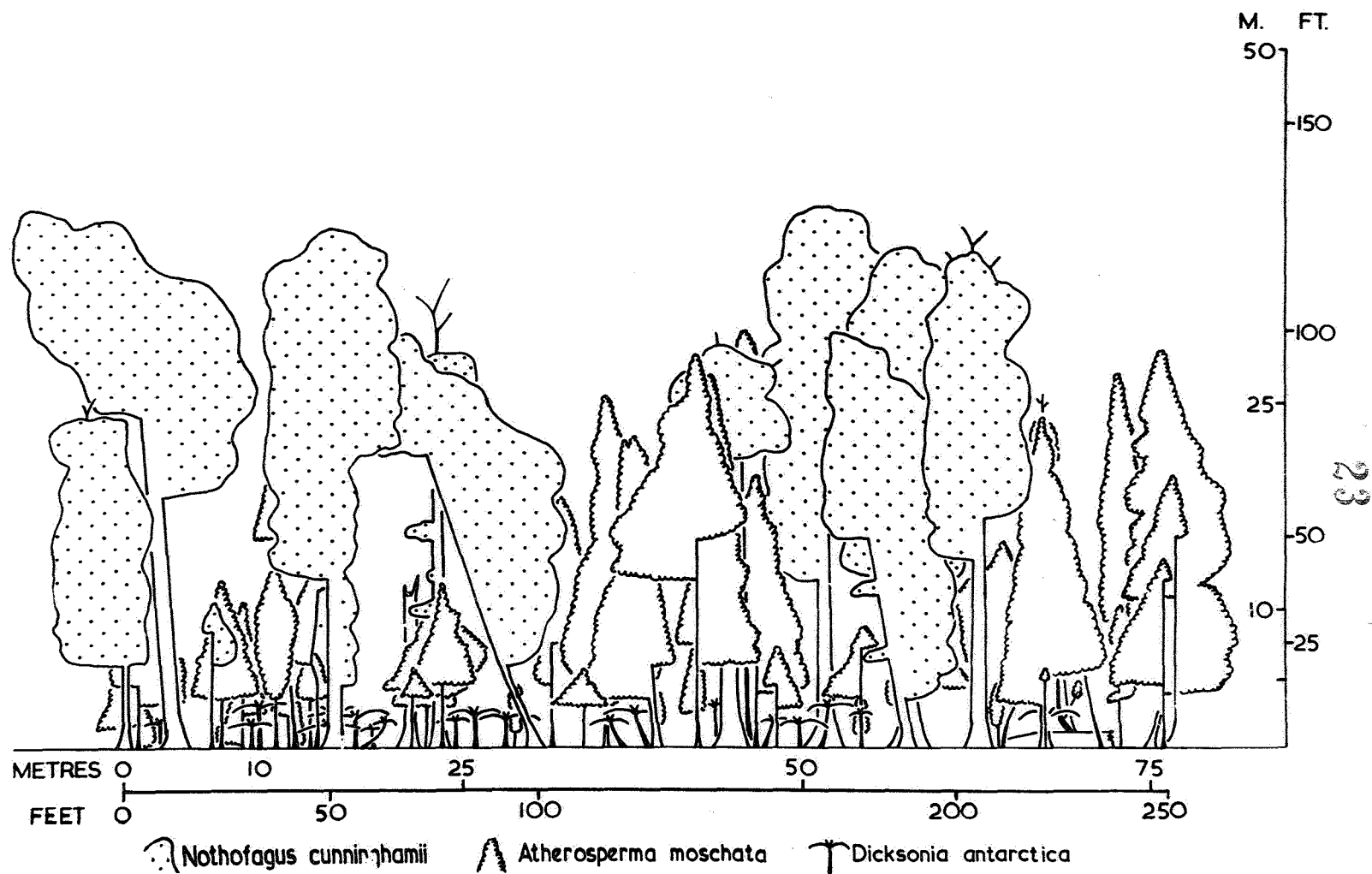


Fig. 1. 4. Profile diagram of transect in temperate rainforest, Road 7, Florentine Valley. Transect 50ft. wide but *Dicksonia* shown for central 32ft. only.



Fig. 1.5. TEMPERATE RAINFOREST near Companion River, N. W. Tasmania.
Principally Nothofagus cunninghamii with some Atherosperma moschata.

Small Atherosperma occur throughout the transect in numbers far exceeding those of Nothofagus, which suggests that it is the more shade-tolerant species. Large numbers of Nothofagus seed germinate but few seedlings survive beyond the cotyledonary stage. On nearby roadside clearings well established Nothofagus seedlings are present in large numbers.

The tree-fern Dicksonia antarctica forms a broken stratum at 8'-10'. Many of the plants are showing the effects of low light intensities (c.1/100 of that in the open) - mature fronds are often only three feet long and the tops of the trunks are sharply tapered. The forest is very open near ground level - Fig.1.6.

There are few logs on the ground. Atherosperma is not durable and many Nothofagus die "on their feet" (Fig.1.7) and rot away while still standing. Logs, fallen limbs and the ground (except under mature Nothofagus) are more or less completely covered with a layer of liverworts, mosses and lichens. The Bryophytes also grow on most of the tree and fern trunks, and commonly reach a height of 80'-90'. Of the epiphytic ferns, Grammitis billardieri occurs here and there on logs and trunks (sometimes to 80 ft.) members of the Hymenophyllaceae occur on lower trunks, and Phymatodes diversifolium is found at high levels in the crowns of dead and dying Nothofagus.

In Table 1.6 is shown the distribution by girth-classes of the trees depicted in Fig. 1.4 (transect A) and those on a nearby transect (B).

(c) Regeneration in the virgin forest

The distribution of the two species over the range of girth-classes is markedly different. For Atherosperma it shows that a state of continuous regeneration has



Fig. 1.6. Temperate rainforest, Road 7, Florentine Valley.
Atherosperma moschata R. foreground. Behind these trees and in
 L. foreground are two large Nothofagus cunninghamii. Large ferns
 are Dicksonia antarctica.

FIG. 1.7

Nothofagus cunninghamii (large dark trunk and light-grey stump) which had died and were rotting away while still standing.

Atherosperma moschata L. & R.

foreground, show Bryophytes on trunks. Tree fern is

Dicksonia antarctica.

Temperate rainforest, Road 7, Florentine Valley.

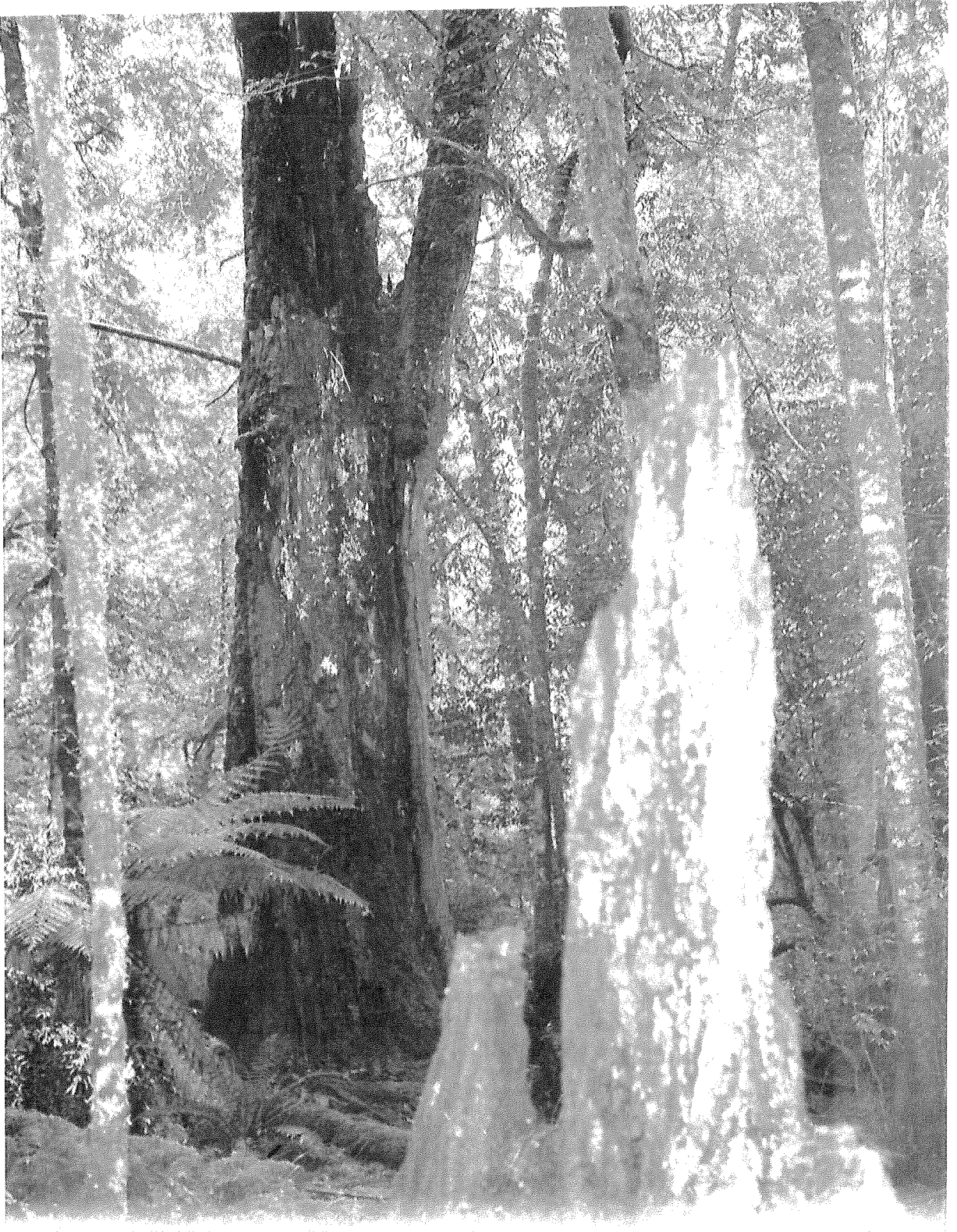


TABLE 1.6

No. of trees per acre, by girth-classes, on two transects in temperate rainforest, Road 7, Florentine Valley.

TRAN- SECT	SPECIES	SHEDDLS. 1'-4'3"	GIRTH BREAST-HIGH - FEET										TOTAL >1' GH.
			0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	
A 250' x 50'	Notho- fagus	6	17	-	3	-	-	-	-	3	3	23	32
	Athero- sperma	404	106	43	57	23	11	6	11	6	-	-	114
B 900' x 33'	Notho- fagus	49	55	10	3	4	-	-	1	-	-	24	42
	Athero- sperma	?											
			592	85	33	21	16	9	-	-	3	-	167

existed in the past. Ring counts confirm that the small trees are young. Recruits to the upper girth-classes are available in numbers which would allow considerable losses to occur among the lower classes without causing a significant fall in numbers in the upper.

Large numbers of Atherosperma are not of seedling origin. Dozens of small shoots may come from low on the trunk of a single tree; many of these shoots will grow to more than 4'3" high and a few will grow to maturity (usually only 1, sometimes 2 or 3 from one parent). It is not uncommon for 1 or 2 of these shoots to have grown to 6-9 ins. in diameter and 50-60 ft. high before the parent stem dies.

Although adventitious shoots are quite common on the lower trunks of old Nothofagus they have not been seen to persist.

In Transect A there are fewer Nothofagus below than above 2 ft. G.B.H. and there are no trees in the range 2-6 ft. G.B.H. All the Nothofagus above 6 ft. G.B.H. are old trees and most would be dead before any of those below 2 ft. girth had reached maturity. In Transect B much the same position is revealed. There is only one Nothofagus between 4 ft. and 8 ft. girth, and to replace the 24 decadent trees above 8 ft. G.B.H. some recruits would have to come from trees less than 1 ft. G.B.H. Gaps in the present Nothofagus canopy are occupied by Atherosperma and additional gaps will develop as the large Nothofagus die (probably in 50-100 years). Because of its advantage in numbers and distribution of young trees, Atherosperma is likely to occupy more and more of the site to the exclusion of Nothofagus.

But this may be only part of a cycle of varying success in the establishment of regeneration. From ring counts made on nearby areas it seems probable that in this

case the absence of the middle girth-classes of Nothofagus represents a gap of 200 years in successful regeneration. Jones (1956) reports a paucity of middle sizes in most of the emergent species in tropical rain-forests in Southern Nigeria. The trees below 4 ft. girth on transects A and B look young - this is indicated by the character of the fissuring of the bark, the amount of moss on the trunks and limbs, and the shape of the crown. By contrast the trees in the upper-girth classes look very old and some are nearly dead. On the basis of ring-counts made on nearby areas it is considered that the stand is at least 500 years old.

(d) Age determinations

The age determinations of Nothofagus on nearby areas were made from counts of annual rings on stumps and logs of trees felled for saw-logs. The older trees were very rotten at stump-height (4-6 ft) but at 15 ft. or so from the ground were generally sound enough for complete counts to be made. Radial increments were found to be very low, particularly during the last 100-200 years of the life of the tree. The mean number of rings per inch was 15.6 for all sections counted. Averages of 20 rings per inch were noted over the last 100-200 years of the life of some trees and many old trees had 40 rings per inch. Such trees have very rotten butts and their crowns contain some dead limbs. It is doubtful that they would live for more than another 50 years. Yet many such trees yield logs sound enough for milling.

The highest count gave an age of 450 years and several gave about 400 years. Field counts are made with difficulty but it is clear from the age of old eucalypts still growing in some of the stands where the counts were made, that the ages of the Nothofagus are of the right

order of magnitude. The relation between the age of the eucalypts and rainforest species in mixed forests will be discussed later. Although the greatest age attained by Nothofagus has not been established with certainty it is reasonable to assume that it is 450-500 years.

Atherosperma reaches little more than half the age of Nothofagus. Mr. A. B. Mount of the Tasmanian Forestry Commission has informed me of a count of 250 years in the Styx Valley. In the Florentine where the Nothofagus counts mentioned above were made, nine trees of Atherosperma ranging in G.B.H. from 4'6" to 7'5" had counts of 180-240 years. No other trees were seen that were larger than 7 ft. G.B.H. but it would be surprising if there were not some older ones. However it is certain that the Atherosperma which germinated at the same time as the old Nothofagus have died and rotted away and that Atherosperma has been in a continuous process of regeneration and death. Once decadent, Atherosperma dies quickly and rapidly rots so that few dead and dying trees remain in the stand. One Atherosperma, felled for saw-logs, was typical. The tree was 6 ft. in girth and 102 ft. high. Foliose and bearded lichens, mosses and ferns grew on the branches and trunk in great abundance even more than 80 ft. above the ground. The centre of the stump was rotten for a radius of 3 ins. and outside this, 180 rings could be counted so that the tree was about 225 years old and would probably have deteriorated rapidly in the next 25 years. At 3'6" from the ground a side shoot with a diameter of 7.5 ins. was found to be 100-110 years old. When this shoot first appeared the parent tree must have been 80 ft. or so high.

From measurements made in several parts of the

Florentine it appears that Nothofagus does not often exceed 120-130 ft. in height, even though a height of 115-120 ft. may be reached in less than 150 years. Thereafter the crown spreads and becomes more dense. Atherosperma can reach 100 ft. in height in 150 years.

(e) Litter layer

Near old trees of Nothofagus the mineral soil may be covered with litter to a depth of a foot or so, although usually this layer thins to 1-3 ins. within a few yards of the tree. When the stand consists mainly of Atherosperma the litter layers are very thin and the mineral soil can be exposed with a rake or the fingers. Quite often the litter layer is virtually absent. This is remarkable under conditions of full canopy, cool temperature and moderately heavy rainfall. It is one of several features of Atherosperma worthy of investigation.

Fairly extensive stands of Atherosperma occur in which Dicksonia is often the only other plant besides liverworts, mosses and lichens. These relatively pure stands exhibit some peculiar features which will be discussed later (see V. Development of the Climax Types).

B. MIXED FOREST

In order of decreasing abundance the eucalypt species are regnans, gigantea, obliqua, viminialis and ovata. As is usual in Tasmania, gigantea is the most important forest tree above 1800-2000 ft. but in the Florentine it is also not uncommon on the floor of the valley (below 1500 ft.). Below 2000 ft. the relative ecological position of regnans, obliqua and gigantea requires considerable investigation. In general the forest consists of a series of fairly extensive even-aged stands. The distribution of ages is quite irregular, there being large areas of the following (as in 1957) - 23, 120, 150, 205, 315 and 400 plus years. Other ages have been reported but they probably occupy small areas. As will be discussed later, the large even-aged areas must have arisen from past fires, for with a fire-tender species like regnans, survival even of adult trees is unusual except at the dying margin of a fire. With more fire-resistant eucalypts such as obliqua many trees may recover after fires so that there is often an intimate mixture of many ages, particularly on poor sites.

(a) Mixed Forest (175-400 years) Fig. 1.2

This forest consists of very large eucalypts (regnans, obliqua or gigantea) with a mean density often less than five trees per acre, growing over a fully-developed understory of rainforest species. The structure of the understory differs little from that of pure rainforest. At ground level the light intensity is as low as in rainforest - c.1/100 of that in the open.

Measurements have been made on three transects.



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Fig. 1.8. Old mixed forest, Road 10, Florentine Valley. Eucalyptus regnans with understory of Nothofagus cunninghamii and Atherosperma moschata and stratum of Dicksonia antarctica.

Transect 1. Road 10, Florentine Valley (Figs. 1.8 and 1.9)

Comparing the appearance of the eucalypts with stands of known age it was estimated that this stand was over 300 years old. All the eucalypts were apparently the same age.

The number of regnans (11 per acre) is high for old mixed forest.

The four regnans on the transect had the following dimensions:

	<u>Mean</u>	<u>Maximum</u>
Girth-breast-high	29.5'	42.0'
Total height	220'	250'
Crown spread	40'	55'
Crown depth	145'	180'

Crowns are stag-headed.

As in all mixed forests, eucalypt seedlings, saplings or poles are absent.

The dominant trees of the understory are Nothofagus. In Table 1.7 the five largest Nothofagus and Atherosperma on this transect are compared with those on the transect described in rainforest.

TABLE 1.7 Comparison of the 5 largest Nothofagus and Atherosperma in rainforest and mixed forest. Measurements in feet.

SPECIES	TRANS-ECT	G.B.H.		TOTAL HT.		CROWN SPREAD		CROWN DEPTH	
		Mean	Max	Mean	Max	Mean	Max	Mean	Max
Nothofagus	Rain forest.	16.5	19.0	125	130	40	58	80	85
	Mixed forest.	12.5	21.0	100	115	35	50	75	100
Atherosperma	Rain forest.	5.7	6.5	95	100	30	35	75	80
	Mixed forest.	5.5	8.75	90	95	25	25	70	80

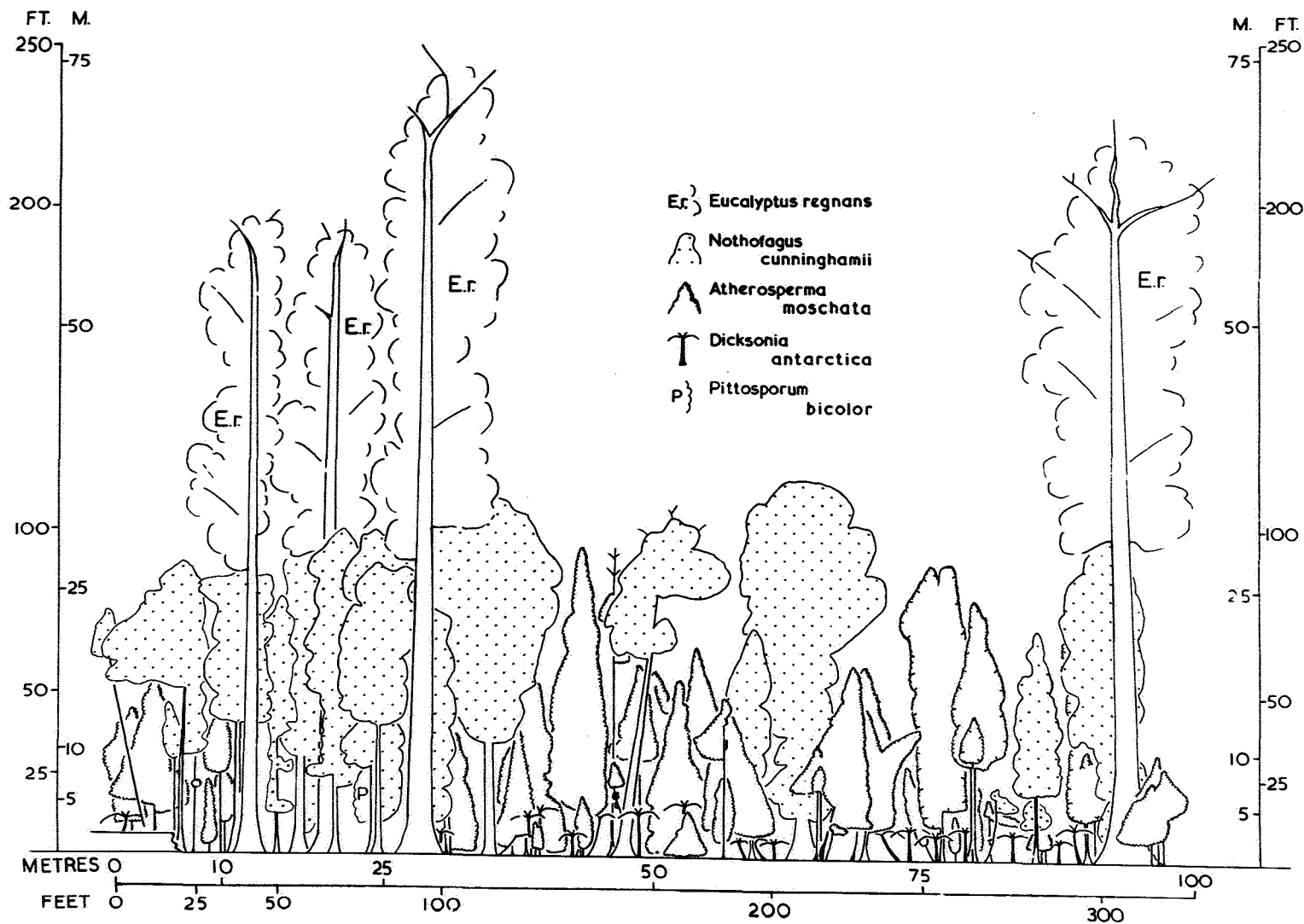


Fig.1.9 Profile diagram of old mixed forest Road 10, Florentine Valley.
Transect 50ft. wide but Dicksonia shown for central 32ft. only.

On the basis of the five largest trees (rate 14 per acre) the pure rainforest is not markedly different from the understory in the old mixed forest except that the trees of Nothofagus in the mixed forest are smaller. As the samples are small and the site differences potentially so large these size differences need not be significant.

The distribution of the trees by girth-classes is shown in Table 1.8.

Compared with the transect in pure rainforest (Table 1.6) the mixed-forest carries many more Nothofagus above 1 ft. G.B.H. (with the increase in numbers mainly in the smaller girth-classes). Furthermore there is some representation in all classes. The contrast between Nothofagus and Atherosperma in the distribution of stems by girth-classes is of the same pattern in both cases, Atherosperma exhibiting a relative predominance of seedlings, Nothofagus of adults.

Transect 2. Styx Valley.

The result of an assessment, on a 10 chain x $\frac{1}{2}$ chain transect in old mixed forests in the Styx Valley, is shown in Table 1.9.

The age of the forest was not known but although the eucalypts were smaller (mean G.B.H. 20 ft.) they were probably about the same age as those of the Road 10 transect - over 300 years. The site of the Styx transect was not ideal for regnans, being on a steep ridge which would probably carry obliqua if the rainfall were somewhat lower.

Bearing in mind that the sample is small ($\frac{1}{2}$ acre), the figures suggest that successful regeneration of Nothofagus has not been continuous. The future status of Atherosperma is clear enough but this is not the case with Nothofagus.

TABLE 1.8

No. of trees per acre, by girth-classes, on transect in old mixed forest. Road 10, Florentine Valley. Transect 320 x 50 ft.

SPECIES	SEEDLGS. 1'- 4'3"	GIRTH BREAST HIGH - FEET											TOTAL >1' GBH.
		0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8		
E. regnans	-	-	-	-	-	-	-	-	-	-	11	11	
Nothofagus	22	71	8	24	3	11	3	3	5	3	14	66	
Atherosperma	327	193	120	57	24	22	8	3	-	-	3	117	
Pittosporum	-	-	-	3	-	-	-	-	-	-	-	3	

TABLE 1.2

No. of trees per acre, by girth-classes, on transect in old mixed forest. Styx Valley. Transect 660 x 33 ft.

SPECIES	SEEDLGS. 1'- 4'3"	GIRTH BREAST HIGH - FEET											TOTAL >1' GBH.
		0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8		
E. regnans	-	-	-	-	-	-	-	-	-	-	6	6	
Nothofagus	6	106	20	16	-	-	8	2	4	2	8	40	
Atherosperma	176	720	164	114	50	28	10	6	-	-	-	208	
Olearia	-	-	-	2	-	-	-	-	-	-	-	2	



Fig.1.10 Mixed forest, Florentine Road, Upper Tyenna Valley. Eucalyptus obliqua with some E. gigantea. Understory of Nothofagus cunninghamii and Atherosperma moschata (light coloured crowns)

Transect 3. Upper Tyenna Valley. (5½ mile, Florentine Road) Figs. 1.10 and 1.11

The site of this transect was at first considered to be poorer than Road 10 for the following reasons:-

1. regnans is replaced by gigantea and obliqua, the latter being considered to indicate poorer sites
2. the canopy of the understory here is much more broken than at Road 10
3. Eucryphia and Anodopetalum are common in the vicinity, but just failed to get within the limits of the transect. These are two of several species usually regarded as indicative of fairly poor sites.

However, tree height is recognized as a good index of site quality, which basically is the capacity of the site to produce wood. In this case the eucalypts have grown to 250 ft. and Nothofagus to 130 ft. Such heights indicate a site of high quality, and are of the same order as those of the Road 10 area. It must be concluded that the broken canopy of the Nothofagus on the transect in the Tyenna Valley had resulted from an initially poor stocking rather than from a poor site.

The number of trees per acre is shown in Table 1.10.

The number of eucalypts was above average for the surrounding forest, for which 5-10 per acre is a reasonable estimate.

Compared with Road 10 there are only half as many Nothofagus above 1 ft. G.B.H. and far fewer small trees and seedlings. The 33 seedlings of Nothofagus shown in Table 1.10 were not dispersed throughout the transect but on the soil among the roots of one fallen dead tree, and almost all the small Atherosperma were suckers on the

TABLE 1.10 No. of trees per acre, by girth-classes, on transect in old mixed forest, Tyenna Valley 5 1/4 mile, Florentine Road.
Transect 345 x 50 ft.

SPECIES	SEEDLGS. 1'- 4'3"	GIRTH BREAST HIGH - FEET											TOTAL >1' GHH.
		0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8		
E. obliqua ^x	-	-	-	-	-	-	-	-	-	-	-	13	
Nothofagus	33	28	10	3	3	-	3	3	-	-	-	30	
Atherosperma	397	126	28	45	15	20	25	5	3	-	-	113	
Pittosporum	-	-	-	3	-	-	-	-	-	-	-	3	

x Fallen twigs indicate that some of the trees were gigantea but the standing trees could not be separately identified.

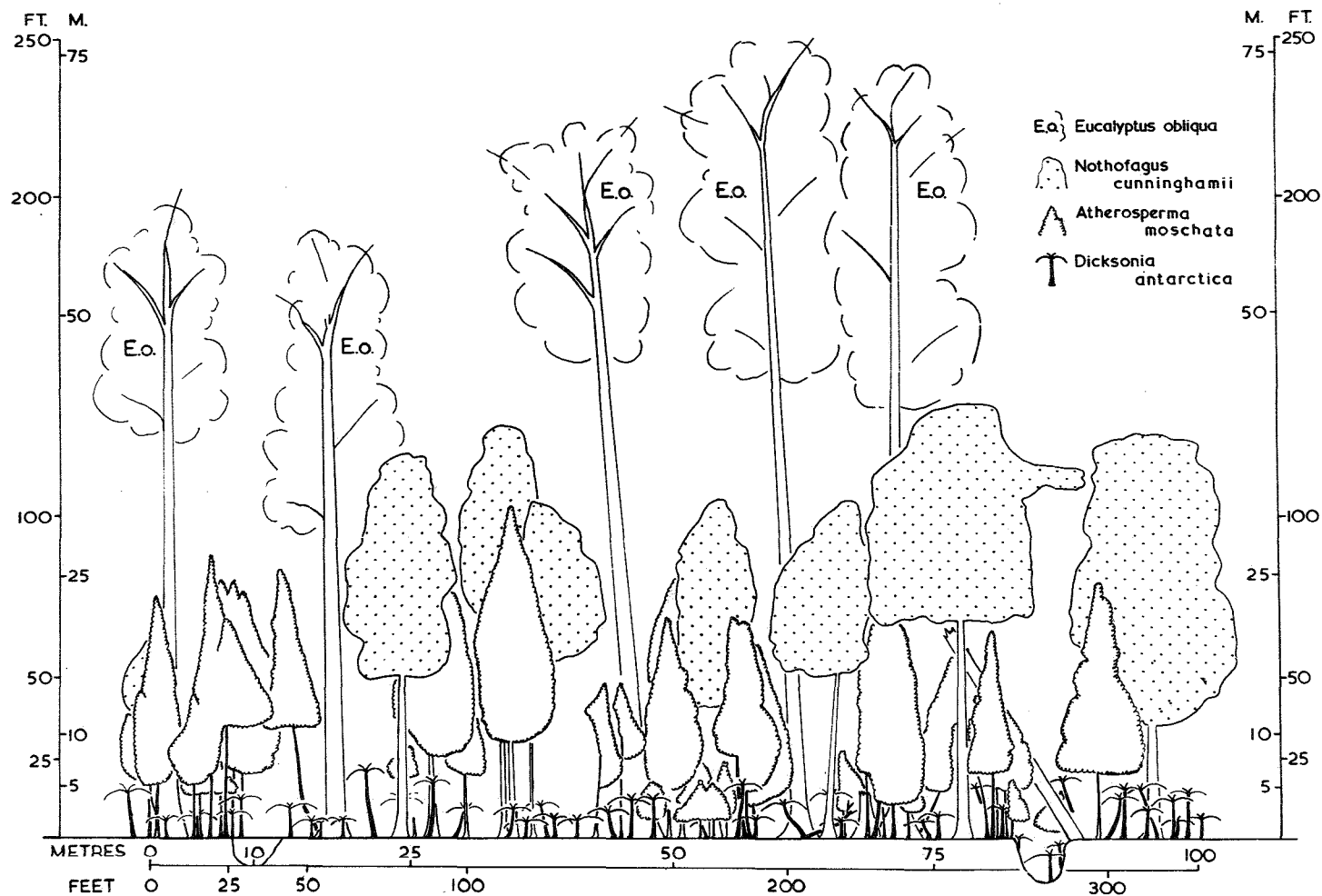
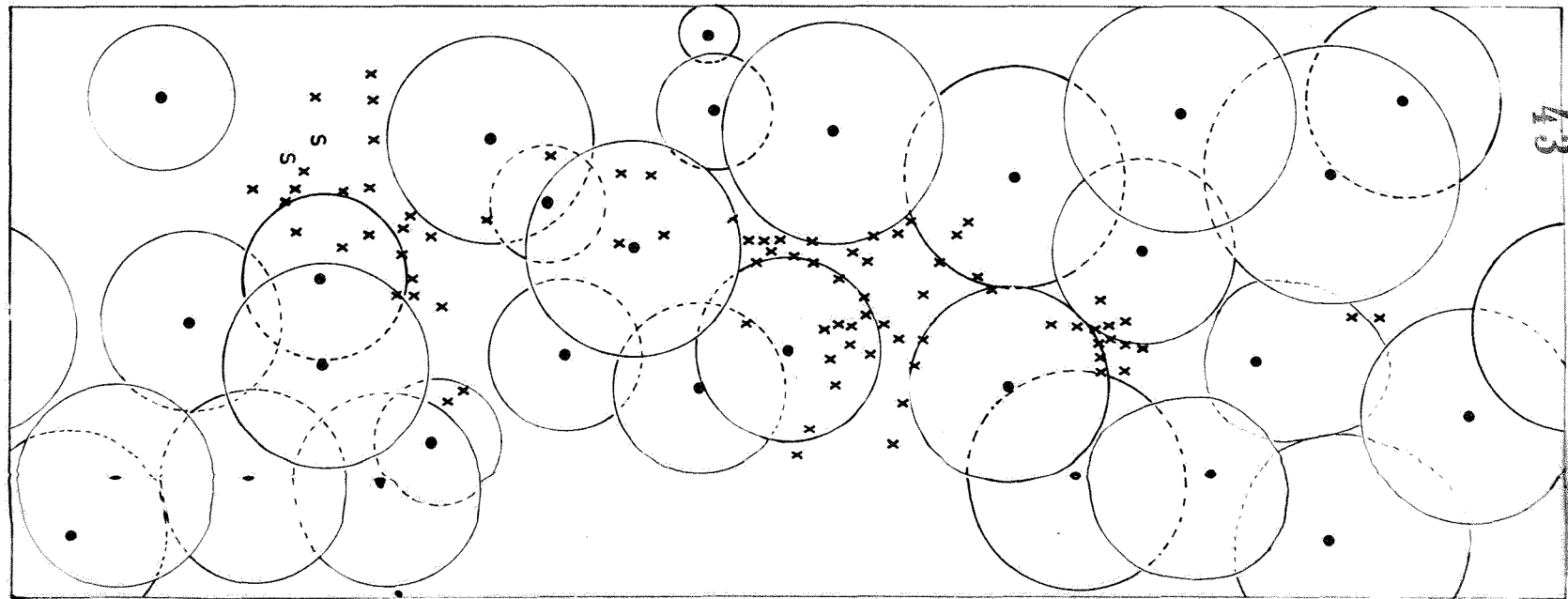
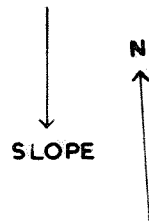


Fig. 1.11. Profile diagram of transect in mixed forest, 5½m., Florentine Road, Upper Tyenna Valley. Transect 50ft. wide but *Dicksonia* shown for central 32 ft. only.

TRANSECT ACROSS GAP IN RAINFOREST CANOPY Dicksonia Canopy and Ground Stratum.

- *Dicksonia antarctica*
- x *Polystichum proliferum*
- S *Sassafras* Seedlings
(*Atherosperma moschata*)

Scale: 1 in. = 8 ft.



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Fig1.12 Transect in forest depicted in Figure 1.11. Plot 32 ft. x 81 ft.

butts of standing trees. The broken canopy of the understory had enabled Dicksonia and other ferns to grow vigorously and conditions approached those to be found in a fern gully where seedlings of tree species become established only with difficulty - Fig. 1.12.

(b) Young mixed forests

Young mixed forests (age 100-150 years) occur principally towards the northern end of the study area (Fig. 1.2(b)) and to the north and north-west of it. Those within the study area generally comprise regnans (height 250 ft) with an understory of Nothofagus (to 120 ft), Atherosperma (to 100 ft) and very occasional Acacia melanoxylon and Pittosporum. Coprosma billardieri and Clematis are occasionally found.

Officers of the Forestry Commission and Australian Newsprint Mills have made counts of the number of live eucalypts on several one-acre assessment plots in young mixed forest. Thirty regnans constitute full-stocking in 150 year-old stands. Such fully-stocked stands contain some eucalypts which have recently died or are about to die presumably because of competition for room in the stand. Understory trees of Nothofagus and Atherosperma occur throughout such stands and where the eucalypts are locally less dense may reach heights of 120 and 100 feet respectively in 150 years (Figs. 1.13 and 2.2). The canopy of the understory is not complete, with the crowns of Nothofagus just becoming flat-topped but still relatively narrow. During the next 50 years, as a few more eucalypts die, the understory will gradually assume the appearance of rainforest with eucalypts towering above it.

As with the older mixed forests, the eucalypts are in even-aged stands i.e. there is a complete absence of eucalypt seedlings and saplings.



Fig.1.13 Eucalyptus regnans 150 years old, Lords block, Florentine Valley. Regnans 250ft. high and understory 100 ft. Nothofagus cunninghamii left foreground.

C. EUCALYPT FOREST

This includes all stands of eucalypts in which rainforest species at present play a minor role.

(a) STANDS ON SOILS OF MODERATE TO HIGH FERTILITY

(i) MIXED FOREST AFFECTED BY THE 1934 OR LATER FIRES.

From counts of annual rings it appears that no widespread fires occurred between the 1840's and 1934 when a fire spread from the vicinity of Dawsons Road southwards for eight miles. Its southward spread was obviously assisted by the presence of large areas on the floor of the valley which had recently been savannah and by inflammable vegetation on the series of low ridges of silicified limestone.

Fires which burn through mixed forest usually kill all the eucalypts, particularly where the eucalypt component is the fire-sensitive regnans. Although a few eucalypts may survive, trees of the understory rarely escape destruction. The general pattern of fire behaviour will be discussed in a later section (V. The role of fire in forest succession).

Mixed forest completely destroyed by the 1934 fire.

The resultant stand could be classified as young mixed forest for the essential components are present, both eucalypt and rainforest species. However the rainforest species are of little significance in the present stand (just over 20 years old) and several seral species are present: Acacia dealbata, Olearia argophylla, perhaps a few Pomaderris apetala and the last traces of fireweed species such as Senecio australis and Erechtites prensanthoides. Small trees and shrubs which are

rare in mature mixed forest are not uncommon e.g. Coprosma billardieri, Pittosporum bicolor, Clematis aristata. Depending on the density of the eucalypt regeneration and the locality, a fern stratum 3-4 ft. high and of greatly varying density and continuity is usually present. The most common species are Histiopteris incisa, Polystichum proliferum, Hypolepis rugosula and Blechnum procerum. This fern stratum will practically disappear if the canopy of rainforest species becomes more or less complete or the stratum will become fairly general, with locally dense patches, if this canopy remains broken.

Few measurements have been made in the stands of eucalypt regrowth resulting from destruction of mixed forest by the 1934 fire. Early growth of Nothofagus and more particularly Atherosperma may be ^{so} slow (often 2-6 ins. in height in three years) that ring counts may falsely indicate that the rainforest species are younger than the eucalypts. Thus in a 22 year-old stand of regnans, Nothofagus gave counts of 18-20 years. In a stand of gigantea, ring-counts of gigantea and Nothofagus were the same - 22 years. The mean dominant heights in the 22 year-old stand were regnans 80 feet, Nothofagus 25-30 feet and Atherosperma smaller.

Mixed forest destroyed by fire since 1934.

The areas included here are those logged by Australian Newsprint Mills since about 1950 and on which logging slash has been burnt. Conditions are somewhat artificial but in many small patches only slightly so. Large numbers of quadrats have been examined and the general rule is that there is fairly immediate and coincident germination of all species which are likely to be present from year 1 to year 400 or so, when the last eucalypts die of old age and the site is left

occupied by rainforest.

Mixed forest burnt in 1934 and again in 1948.

By fire or axe man can put the succession back to year 1, but should a second disturbance come before all the tree-species are producing seed a different successional pattern would follow.

An area of mixed forest which was burnt in 1934 was burnt over again in 1948. The second fire killed the rainforest species - the incipient understory - so that now there is only a fern stratum.

In places the 1948 fire was not hot enough to kill all the 14 year-old eucalypts (regnans and gigantea). Some seed would be carried by the 14 year-old eucalypts and scattered regeneration followed the fire. The only survivors of the pre-1948 understory are coppice shoots of Nothofagus and Atherosperma with the latter far more abundant.

The second fire has drastically reduced the stocking of tree-species and allowed the development of the dense fern stratum, about four feet in height. Tree seedlings growing below the level of this stratum will emerge slowly and suffer heavy losses. In their present condition ferns allow few new seedlings to become established and are likely to do so for many decades where tree-species are entirely absent. As tree seedlings develop, modification of the fern stratum will allow new shade-tolerant seedlings to become established and progression to more normal forest conditions would then proceed at a much faster rate.

(11) AREAS RECENTLY OCCUPIED BY TREE AND SHRUB SAVANNAH.

The occurrence in the recent past of tree and shrub savannah over several hundred acres in the central Flor-entine was first reported by Jackson (1956). Only a brief description can be given here of the eucalypt stands on these areas.

It is probable that the savannah was made up of two sub-associations:

1. Drimys aromatica - Hakea microcarpa: Poa caespitosa shrub savannah; and
2. E.ovata - E.viminalis - Acacia dealbata: Poa caespitosa tree savannah.

It appears that physiography and climate would have allowed the area to be occupied by mixed forest or rain-forest. Two factors which may have been responsible for the maintenance until recent times of savannah conditions are as follows:

1. Repeated burning. Although the savannah is now rapidly progressing towards closed forest, the area is still attractive to wallabies and other marsupials. Under savannah conditions native animals would have been even more plentiful and the area attractive to the aborig-ines who used fire freely both to hunt game and to attract it to the fresh plant-shoots which follow fires.

2. Most of the area appears to be associated with the deepest sheets of the unconsolidated material referred to under "Geology". Water does not lie in the bottom of pits opened in these deposits for road-surfacing material and the deposits overlies cavernous limestone. It is probable that the water-holding capacity of the material is very poor.

The replacement of the savannah by eucalypt forest is probably the result of an increase in rainfall with an attendant decrease in fire frequency. The disappearance of the aboriginals 130 years ago may have resulted in a lower frequency of fires but as many of the eucalypts are more than 200 years old, the change to eucalypt forest commenced before white-men settled in Tasmania. A few small treeless patches are all that remain of the shrub savannah, Bakea microcarpa surviving with difficulty, while most other plants are smothered by bracken. Only a few tussocks of Poa and Cyperaceous species have survived except in a few small areas where the winter water-table is at ground level. Here Poa caespitosa is present as large hummocks.

In the succession to mixed forest, the order of appearance of the eucalypts is ovata, viminialis and regnans, with Acacia dealbata present throughout the succession and sometimes the pioneer tree-species ahead of ovata. The species of the shrub-savannah do not survive for very long in the eucalypt forest with the exception of Drimys which may build up to a continuous stratum, 15-20 ft. high in the ovata-viminialis association. Thereafter it diminishes in frequency to become rare in mixed-forest.

Acacia melanoxylon, Olearia argophylla, Pomaderris apetala, Pittosporum bicolor, Coprosma billardieri and Phyllocladus asplenifolius reach their peak frequency with the advent of regnans but they are usually scattered trees of park-like habit i.e. they have deep, very wide crowns. A few Atherosperma appear but Nothofagus is rare.

In the regnans-viminialis association the viminialis are very large trees of good form. Without disturbance of the site it is assumed that this association would change to pure regnans, because regnans with its faster rate of growth would suppress viminialis in most spots

suitable for regeneration. It is possible that the understory will develop quickly enough to prevent eucalypt regeneration. However part of the regnans-viminalis association was partially burnt by the 1934 fire and many more regnans than viminalis were killed. The resulting eucalypt regeneration consists of 50 ft. saplings of regnans with 6 ft. viminalis as part of a discontinuous stratum of shrubs (Fig. 1.14). The shrub layer is quite different from that in mixed forest burnt in 1934, Nothofagus and Atherosperma being virtually absent. The commonest shrubs and tree seedlings of this forest are rare in the mixed forest. They are Drimys, Acacia dealbata, Acacia melanonglon, Phyllocladus, Coprosma, Zieria arborescens, Olearia argophylla and Pomaderris. Several Epacridaceous species are present and one, Astroloma humifusum is quite alien to forests.

The area once covered by savannah has been important because it provided an easy path for fires along the floor of the valley.

(iii) AREAS BURNT THREE TO FOUR TIMES IN THE LAST ONE HUNDRED YEARS BY FIRES OF LOW INTENSITY

The stands on these areas have arisen because of the abortive effort at agriculture at Dawson's Road ("The Settlement"). Dawson's Road was built in 1847 as the beginning of a "road" link (uncompleted) to the West Coast. The first blocks of The Settlement were selected in 1904 and a start made in the following year to clear several hundred acres of mixed forest by felling, ring-barking and burning. By the early 1930's much of the cleared land was being over-run by bracken and scrub and attempts were made to halt this invasion with fire. Many fires spread into adjoining mixed-forest and greatly modified it. The eucalypt component became of mixed age



Fig. 1.14. Forest of Eucalyptus regnans and E. viminalis burnt in 1934. Dead trees are regnans and large trees behind them and in left foreground are viminalis. Large saplings (50ft.) are regnans with some Acacia dealbata. Viminalis regeneration is 6 ft. high, under the regnans saplings.

and the simple Nothofagus-Atherosperma understory was largely replaced by Acacia dealbata, Olearia argophylla and Pomaderris with a few Acacia melanoxylon. Regeneration of Atherosperma occurred but, except for occasional trees, not of Nothofagus.

Even though Atherosperma occurs through the whole stand and is not confined to gullies, the structure and floristics in these areas resemble that of wet sclerophyll forest in the 40-50" rainfall zone. It is similar to much regnans forest in Victoria. At Wallaby Creek, Ashton (1956 - unpublished thesis) found the understory of Pomaderris, Olearia and Acacia (dealbata) was commonly 40 years of age and he had to search carefully to find one that was older (80 years). Unless further fires occur it seems that no further regeneration of eucalypts will occur in the Dawson's Road stands and that the sub-climax would be temperate rainforest with a broken canopy in which there would be a marked increase in the frequency of usually occasional species such as Acacia melanoxylon, Pittosporum and Olearia argophylla and a fairly complete stratum of tree-ferns (Dicksonia).

(b) STANDS ON SOILS OF LOW FERTILITY (Fig. 1.2 (b) - eucalypt forest of mixed age).

Geographically there are two main areas, the more extensive at Tim Shea on conglomerates and quartzites and the other in the floor of the valley on low quartzitic ridges running parallel to the Florentine River on its eastern side. The soils are shallow and very acid.

Eucalyptus simmondsii, as on similar soils elsewhere in Tasmania where the rainfall exceeds 60" or so, occurs in fairly open stands with a relatively rich small tree and shrub stratum in which the families Myrtaceae, Epacridaceae and Proteaceae are strongly represented. The mature height of simmondsii may be as low as 40 ft.

The stands have been greatly modified by frequent fires. There is an intimate mixture of eucalypts of many ages and the shrub layer is usually young and, depending on the time since the last fire, also dense.

With an increase in soil fertility, obliqua and gigantea may occur with simmondsii. Tree height increases and understory trees are more numerous. With a further increase in soil fertility shrubs are generally mesomorphic instead of generally xeromorphic and simmondsii goes out and regnans comes in.

D. TREELESS AREAS

Except for a few small remnants of shrub savannah in the middle Florentine, together with rock and scree slopes of the Field West Range, treeless areas are confined to fairly extensive areas of poor, acid soils developed on the conglomerates and quartzites of Tim Shea ("Sedgeland"-Fig. 1.2(b)). Around the foot of the mountain a few, very poorly drained flats probably constitute the only edaphic climax for Mesomelaena sedgeland. Elsewhere sedgeland and wet scrub have been maintained by frequent burning.

On the West Coast, freedom from fires would allow such areas of wet scrub to proceed through the stages of eucalypt forest and mixed forest to rainforest (Jackson 1958), but on Tim Shea it is doubtful whether the succession would go beyond the mixed-forest stage, even if fires were excluded, because the rainfall is probably too low (just above 60") for the maintenance of rainforest on such poor, shallow soils.

E. SUMMARY

The changes in plant associations and floristics with changes in soil fertility and fire frequency are summarized in Table 1.11. The table has been divided into four fertility-gradings x four fire-frequencies, in order to illustrate the changes more clearly. The cells are certainly not of equal "dimensions", neither are the trends in ordered lines.

Eueryphia is included with caution. It is fairly common in the upper Tyenna Valley but not in the Florentine Valley below 2000 ft. The genera are arranged in a subjective order of importance.

Shrub and tree savannah are essentially of the past. Fire frequency would have to alter radically to enable eucalypt forest to develop on Tim Shea on soils derived from conglomerates and quartzites. For this reason the forest type to be found on soils of very low soil-fertility, given very low fire-frequency, is labelled "Future" in the table.

TABLE 1.11 Changes in plant associations and floristics according to changes in soil fertility and fire frequency in the Florentine Valley.

FIRE FREQU- ENCY.	SOIL		FERTILITY	
	HIGH	→	→	LOW
L O W	<u>RAIN FOREST</u>	<u>RAIN FOREST</u>	<u>RAIN FOREST</u>	<u>(FUTURE)</u> <u>MIXED FOREST</u>
	Nothofagus	Nothofagus	Nothofagus	Eucalyptus
	Atherosperma	Atherosperma	Atherosperma	simmondsii
	Dicksonia	Pittosporum	Phyllocladus	Nothofagus
		(Eucryphia)	Anodopetalum	Phyllocladus
		Aristotelia	(Eucryphia)	Leptospermum
		Clematis	Anopterus	Anodopetalum
		Dicksonia	Cenarrhenes	Atherosperma
				Agastachys
				Cenarrhenes
I N C R E A S I N G	<u>MIXED FOREST</u>	<u>MIXED FOREST</u>	<u>MIXED FOREST</u>	<u>EUCALYPT</u> <u>FOREST</u>
	Eucalyptus	Eucalyptus	Eucalyptus	Eucalyptus
	regnans	obliqua	obliqua	simmondsii
	obliqua	gigantea	gigantea	
	gigantea	regnans	simmondsii	
	Nothofagus	Nothofagus	Nothofagus	Nothofagus
	Atherosperma	Atherosperma	Phyllocladus	Phyllocladus
	Dicksonia	Acacia	Anodopetalum	Anodopetalum
		melanoxydon	Leptospermum	Cenarrhenes
		Pittosporum	Atherosperma	Anopterus
		(Eucryphia)	Cenarrhenes	Leptospermum
		Aristotelia	Anopterus	Monotoca
		Clematis		Bauera
		Dicksonia		

.../ Continued

TABLE 1.11

Continued

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FIRE FREQU- ENCY.	SOIL		FERTILITY	
	HIGH	→	→	LOW
	<u>EUCALYPT FOREST</u>	<u>EUCALYPT FOREST</u>	<u>EUCALYPT FOREST</u>	<u>EUCALYPT FOREST OR WET SCRUB.</u>
	<i>Eucalyptus obliqua gigantea regnans</i>	<i>Eucalyptus obliqua gigantea</i>	<i>Eucalyptus obliqua gigantea simmondsii</i>	<i>Eucalyptus simmondsii</i>
	<i>Pomaderris</i>	<i>Pomaderris</i>	<i>Acacia dealbata mucronata</i>	<i>Acacia mucronata</i>
	<i>Olearia</i>	<i>Olearia</i>		
	<i>Acacia dealbata melanoxylon</i>	<i>Acacia dealbata</i>	<i>Leptospermum</i>	<i>Leptospermum</i>
	<i>Atherosperma</i>	<i>Phebalium</i>	<i>Banksia</i>	<i>Melaleuca</i>
	<i>Nothofagus</i>		<i>Gahnia</i>	<i>Banksia</i>
	<i>Dicksonia</i>		<i>Bauera</i>	<i>Agastachys</i>
				<i>Sprengelia</i>
				<i>Monotoca</i>
	(PAST) <u>TREE SAVANNAH</u>	(PAST) <u>SHRUB SAVANNAH</u>	<u>WET SCRUB</u>	<u>SEDGELAND OR WET SCRUB</u>
	<i>Eucalyptus ovata viminalis</i>	<i>Drimys</i>	<i>Leptospermum</i>	<i>Mesomelaena</i>
		<i>Hakea</i>	<i>Melaleuca</i>	<i>Melaleuca</i>
	<i>Drimys</i>	<i>Coprosma</i>	<i>Banksia</i>	<i>Leptospermum</i>
	<i>Hakea</i>	<i>Epacridaceae</i>	<i>Acacia mucronata</i>	<i>Restionaceae</i>
	<i>Acacia dealbata</i>	<i>Poa</i>	<i>Agastachys</i>	<i>Sprengelia</i>
	<i>Coprosma</i>	<i>Eucalyptus ovata (scattered)</i>	<i>Gahnia</i>	<i>Banksia</i>
	<i>Epacridaceae</i>		<i>Bauera</i>	<i>Agastachys</i>
	<i>Poa</i>		<i>Eucalyptus simmondsii (scattered)</i>	<i>Eucalyptus simmondsii (scattered)</i>

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V. THE ROLE OF FIRE IN FOREST SUCCESSION

1. EVIDENCE OF FIRES

The presence of areas of several thousand acres of even-aged eucalypt forest is in itself strong and perhaps sufficient evidence that widespread fires have occurred in the Florentine during recent centuries. In Tasmania the general windthrow of trees in a stand is rare except over very small areas. It is thus hard to conceive of any agent other than fire being responsible for the large areas of even-aged forest. Over several thousand acres the eucalypts and the largest trees of the understory species are all 150 years old. Similarly there are stands of 400 plus, 315, 205, 120 and 23 years old (in 1957). The 23-year old stands are widespread in western and southern Tasmania and arose from the devastating fires of January-February 1934.

In all stands charcoal is readily found on the surface of the mineral soil after removal of the litter layer. Charcoal is usually absent on the trunks of fire-killed trees of species such as regnans. Few regnans survive a fire so that burnt-out butts with a lining of charcoal are not produced. The cambium of regnans is killed but the bark is rarely burnt from the tree, so that when the bark is shed a clean skeleton remains.

2. CAUSE OF FIRES

The Tasmanian aboriginal used fire freely (Jackson 1958) and there is ample evidence that in his nomadic existence he moved inland from the coast in the summertime. Stone implements have been found on the mountain country

to the east of the Field West Range. As lightning-storms in Tasmania are usually wet, there are few authentic records that lightning has caused forest-fires (Gilbert 1949) although single trees may be set alight. In over 20 years association with forest-fire-control in Tasmania I know of only two cases of forest fires spreading from lightning strikes. One was in the Florentine Valley!

Only under conditions of high fire-danger can a fire burn over several thousand acres of virgin forest of the type found in the Florentine Valley. The prerequisites are a period of several weeks with little rain culminating in one or more days of high temperature, low atmospheric humidity and strong wind. Before 1800 the aboriginal probably started most of the fires. Since 1800, the white man has been responsible. Mixed forest will be perpetuated if burnt before the eucalypts die of old age i.e. if burnt at least once in 350-400 years. Difficult as it may be to burn mixed forest it is reasonable to assume that during a period of 350 years, fire conditions will arise which are at least as severe as white man has experienced during the last 150 years.

3. CREATION BY WILD FIRE OF CONDITIONS FAVOURABLE FOR EUCALYPT REGENERATION

From investigations made into the factors affecting eucalypt regeneration in areas of high rainfall in Tasmania (see Parts Three and Four) it is clear that wild fire creates a situation in virgin, mixed forests which is favourable to eucalypt regeneration. The favourable circumstances would appear to be:-

- (1) the understory is destroyed.
- (2) the forest floor becomes fully lit.

- (3) the litter layer is destroyed.
- (4) some eucalypt seed is destroyed but large numbers of capsules survive on the trees and there is a heavy fall of seed soon after the fire.
- (5) there is a reduction in the number of insects which harvest eucalypt seed.
- (6) extreme fire-danger develops under the influence of intense Southern Ocean depressions, and good rains usually fall with the passage of the cold front associated with these depressions.
- (7) browsing marsupials (principally wallabies) destroy large numbers of eucalypt seedlings and cause a growth check to many more. Openings in the forest are attractive to browsing marsupials but a very large opening created by wild fire would be favourable to seedlings, particularly as the density of the population of browsing animals is low in the surrounding virgin forest. The eucalypt seedlings gain an advantage by weight of numbers and area.

4. FIRE BEHAVIOUR

Eucalyptus regnans, Nothofagus and Atherosperma are not fire resistant, so that fires usually kill all the trees and another even-aged stand develops. However, along fire edges and also scattered within the burn, two-aged stands may occur. The old stand is represented only by eucalypts. Unless conditions are exceptional, forest-fires do most of their damage between mid-morning and dark. Between mid-night and dawn fires advance slowly and sometimes stop running. During the period between late evening to mid-morning the rainforest understory may be killed but under these conditions only a few of the much taller, relatively more fire-resistant regnans.

The same thing occurs where fires die out as rain sets in or in places protected by their topographic position.

5. REGENERATION OF EUCALYPTS IN THE ABSENCE OF FIRE

Many reports have been investigated of eucalypt stands of mixed ages in the Florentine and Styx Valleys which have not been caused by fire, i.e. cases where eucalypt regeneration was believed to have become established in mixed forest without disturbance of the stand by fire. In all cases except one it was possible to demonstrate that the younger age-class had resulted from fire. The exception is worth recording because it depended on a set of circumstances likely to re-occur only very occasionally and so of no importance in the maintenance of eucalypts in mixed forests. A large regnans had fallen across a steep slope and then skidded sideways down a log lying on the ground so that about a tenth of an acre was cleared and in the clearing there was a dense 3-4 ft. layer of ferns, 3 Acacia dealbata saplings and 1 regnans sapling.

Fire is not essential for the re-establishment of eucalypts in all circumstances. Jarrett and Petrie (1929) in dealing with "Pyric Succession" in the Black Spur region of Victoria stated that some Eucalyptus seed, on the ground before the fire, will escape destruction and that the fire or ashes from the fire stimulates germination or else "removes some previously operating inhibiting agent". Observations and sowing-trials in the Florentine do not support these conclusions. Eucalypt seed will germinate beneath the canopy of an undisturbed rainforest understory and if the litter-layer is removed germination is improved. There is however no survival beyond the

cotyledon stage.

Disturbance of the understory is an absolute essential for the successful establishment of eucalypt regeneration. However removal of the understory and many other physical effects of fire can be achieved without fire. Regeneration is usually dense along the sides of roads in a forest. Clearing for road construction removes the understory and bares the mineral soil. Adequate seed is usually available from nearby standing trees. If all the eucalypts are felled on a logged area, regeneration is usually successful if the slash is not burnt, but unsuccessful if the slash, which contains the immediately available seed, is burnt. Replicated sowing trials on various types of seed-bed (in the forest) at various times and with various amounts of seed suggest that the physical effects of the removal of the understory by fire, of the destruction of deep litter and the sudden release of large amounts of seed from standing trees are the factors which cause the usually prolific crops of seedlings which follow fires.

Wild fires have been responsible for the continued existence of Eucalyptus in large areas of mixed forests. It is clear that fires of similar intensity and extent cannot form part of a planned system of regeneration of Eucalyptus. Apart from the risks involved, conditions on a cut-over area are markedly different from those in virgin forest. The logging slash provides fuel for an intense ground fire which destroys the seed in or shed from the capsules on the heads of the felled trees. In virgin forest these capsules would be on standing trees and much seed in them would survive fire.

Similar conclusions have been drawn elsewhere. Thus many of the stands of Douglas fir (Pseudotsuga taxifolia) on the Pacific coast of North America owe their continued existence to past fires (Hansen 1950; Allen 1954). However, as Allen points out it is "fallacious to claim that fire should be used in regeneration treatments just because wild fires have helped to maintain Douglas fir in the coast region".

VI. DEVELOPMENT OF THE CLIMAX TYPES

1. THE PATTERN OF FIRES

Table 1.11 shows the general level of the development of forest types according to soil fertility and the frequency of fires over the last few centuries. Given a low frequency of fires temperate rainforest would be the climax on all but soils of very low fertility, where it would probably give way to mixed forest. But mixed forest cannot develop on the very poor soils with the present fire frequency and so in Table 1.11 mixed forest is labelled as "future" where there is a combination of very poor soil and high fire-frequency. Fires prevent the development of the climax type (rainforest) and the stage reached (fire-climax) is determined by the frequency of fire. Fires tend to be more frequent on areas of low soil-fertility because poor soils carry large proportions of highly inflammable species from families such as Myrtaceae and Epacridaceae.

Because of the frequency with which they can be burnt, areas of low soil-fertility are the sources of fires which may damage the adjoining forest. It is often difficult to start fires in closed forest and most destruction has come from fires invading from areas of poor-quality forest. In the last century white man has changed this to some extent by making agricultural activities the principal source of forest fires. However the main pattern of the forest in the Florentine Valley was established before white man arrived in Tasmania; his principal contribution being the 1934 fire and even the course of this fire was largely determined by what had happened before his arrival.

The winds which are associated with severe fire weather are from the north to north-west. Fig 1.2(a)

suggests that, owing to topographic protection on the west, fire sources in the Florentine Valley are the important ones for the valley itself. There are two main sources. The first is on Tim Shea and the second near Dawson's Road. The sedgeland and eucalypt forest of mixed ages on Tim Shea occupy most of the area of very poor soil derived from conglomerate and quartzite. The plant communities have been repeatedly burnt. The fires have burnt up-hill to the south and south-east (with the "fire" winds) and have not spread to the rain-forest and old mixed forests on the slopes of the range running from Tim Shea to Mt. Field West. It could be argued that the aboriginal did not visit Tim Shea but white man has done so repeatedly as explorer, prospector and hunter and his frequent fires have not travelled to the east.

The Dawson's Road area has been the most important source of fires. Small Poa plains and adjoining savannahs made the area attractive to the aboriginals. White man, coming from the Derwent Valley, thought the valley to be ^agood, large scale agricultural proposition. Most of the young mixed forest shown in Fig. 1.2 (b) is 150 years old. This would have resulted from an aboriginal fire as white man did not settle Tasmania until 1801 and certainly up to 1807 (the year of the fire) was not pushing into areas such as the Florentine. The stand which originated after the 1807 fire is only partly intact, as much of it was burnt in the 1934 fire; but it can be traced as fire-killed spars. It is obvious that the 1807 and 1934 fires followed the same path. With topography, fire source and the direction of the fire wind the same, this is to be expected. It is reasonable to

assume that the fires which regenerated the old mixed forests also came from the lower Florentine but spread further up the valley. Distance and direction from the fire-source is then seen as an important factor in determining the probability of the attainment of climax status. Jackson (1958) has demonstrated this for the Pieman-Waratah region. The presence of rainforest on the steep, west to north-west facing slopes of the Tim Shea-Field West range is made possible because of low fire-frequency due to the long distance from the fire source.

2. FIRE CLIMAX - MIXED FORESTS

(1) Floristic changes after fire

Repeated fires (say three or four times per century) produce a forest stand in which there is so much floristic variability in space and time that the term fire-climax cannot be applied to them. Such stands have been described under "Eucalypt Forest" and it is evident that the future course of their development depends almost entirely on the future history of fires.

In the Florentine Valley, and the areas of Tasmania receiving more than about 50" of rainfall annually, fire is a complicating factor, structurally and floristically. On all but poor soils, freedom from fire leads to temperate rainforest, the simple nature of which has already been described. Fire will cause simplification only if so frequent that regeneration of the forest species is prevented because the source of seed becomes completely depleted. If some of the species are highly fire-resistant, as for example on the central coast of N.S.W., there may be an elimination of only a proportion of the species by repeated fires (Pidgeon 1938). Jarrett and Petrie (1929) regarded the forest fire "as a great simplifying factor in the development of these communities" (regnans forest) and as "leading to increased purity". In such cases the degree of purification is more apparent than real when a detailed examination is made of the species present.

The destruction of mixed forest (eucalypt plus temperate rainforest) by fire arrests the progress to climax rainforest and starts the forest once again on a course of secondary succession, from relatively many to relatively few species. Thus there is an immediate regeneration of all the species present in the previous stand, some in vastly increased numbers, and the appearance of a few short-lived species.

The most common fireweed species is Erechthites prenanthoides with Senecio australis far less common than in areas of lower rainfall. Scattered Erechthites become established in the first season and seed profusely. In the second season there is a dense growth of new seedlings with the first year plants growing again in the second year to produce plants 6 ft. high. Urtica incisa, Cirsium vulgare and Epilobium show a similar build up in numbers in the second year and ferns (Histiopteris, Polystichum and Hypolepis) may form dense patches. Eucalyptus, Nothofagus and Atherosperma appear in large numbers and species which are rare in the virgin forest become common e.g. Clematis, Pittosporum, Coprosma; and Acacia dealbata, not present in mature mixed-forest, appear in very large numbers.

(ii) The development of the eucalypts

Depending on the speed of the development of the more ephemeral fireweed species and the effect of browsing by marsupials, the eucalypt seedlings may grow vigorously from the time of germination or take 3-4 years to get above the competing fireweeds and to recover from browsing. Browsing also reduces the number of seedlings. Wild fires in virgin forests usually result in dense stands of eucalypt seedlings and counts of over 200,000 seedlings per acre have been made on millacre quadrats. This is exceptionally high but would be rapidly reduced in 5 years to numbers not differing from regeneration which originated at the rate of a few tens of thousands per acre. Enough information is available to form a reasonable picture of the reduction in seedling numbers (Fig. 1.15) which is extremely rapid for the first 10 years and very slow from 150 years to 350-400 years when the last eucalypt would be expected to die of old age if the site were not disturbed.

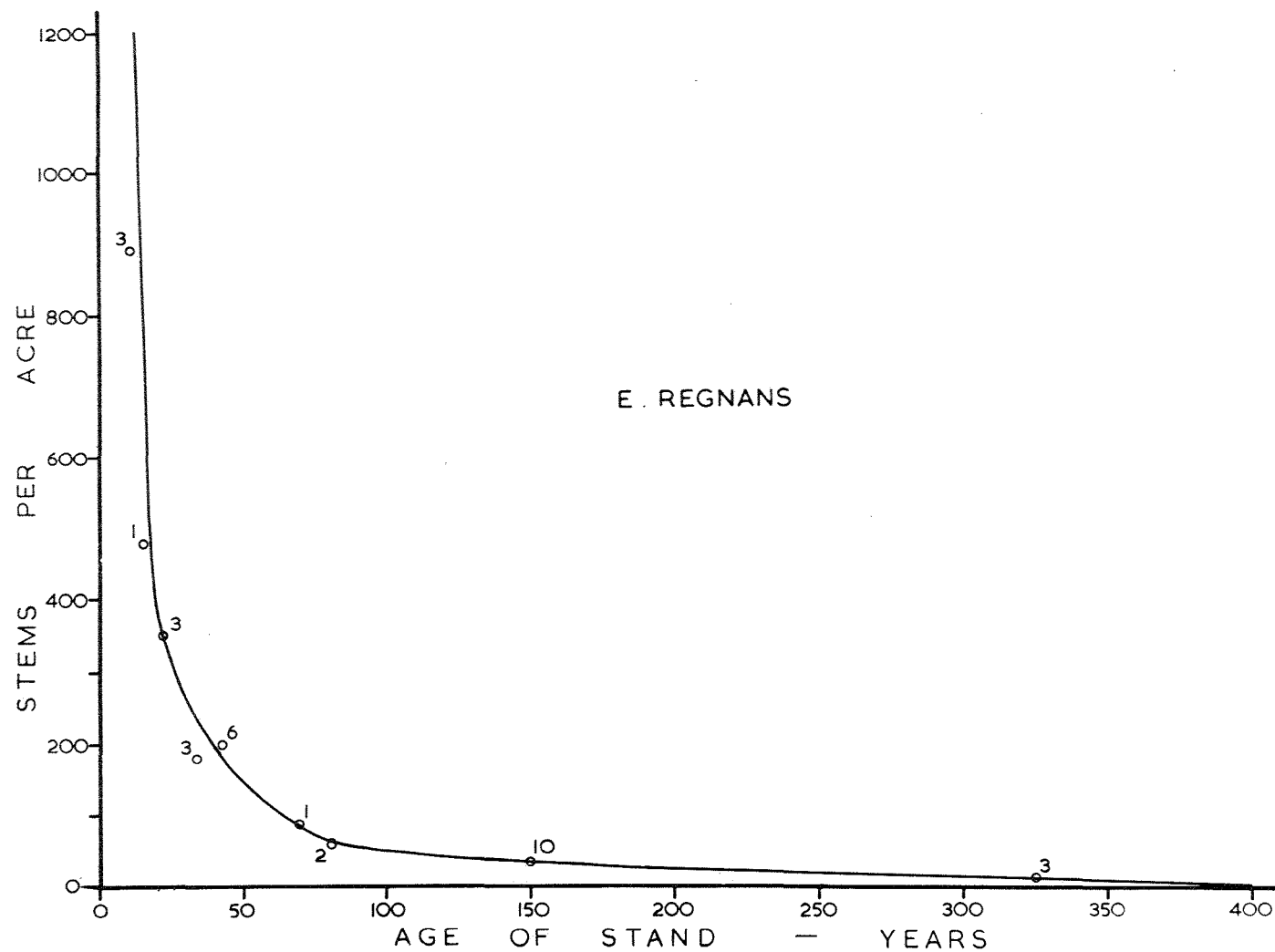


Fig. 1.15. AGE NUMBER OF STEMS relationship for regnans. Information from plots established by the For. & Timber Bureau (3) For. Commission (26) and Gilbert (3) in central and S. Tasmania. Plot sizes varied from $\frac{1}{4}$ ac. for young stands to 1 ac. for old stands. In 3 youngest plots, stems (numerous) less than $2\frac{1}{2}$ " diam. not included; on next oldest, stems (many) less than 12" girth, not included.

Doubt has been expressed as to the correctness of the statement that fire has perpetuated the eucalypts in the mixed forest. It has been suggested that as the eucalypts become decadent they will fall and eucalypt seedlings become established in the breaks made in the canopy. The one known case has been mentioned. It is clear that there has been a great deal of time for such pockets of seedlings to become established. Until the stand is 200 years old (or younger) reduction in the number of eucalypts per acre is mainly due to competition between the eucalypts for room and new eucalypts could not become successfully established even if understory competition were absent. Thereafter there is room for regeneration to become established, if the eucalypts alone are considered, and this condition applies until the last eucalypts die of old age when the stand is c.400 years old. For about 200 years there is an opportunity for the eucalypts to regenerate if suitable gaps appear in the canopy of the understory.

(iii) Regeneration in gaps in the understory

Large gaps in the canopy of the understory are not common in the Florentine. Such gaps as occur are usually caused by single stems of Eucalyptus which fall after their butts have decayed. The dead trees have usually lost most of their crown before they fall. The gaps are generally occupied by Atherosperma which is present as seedlings, saplings or small trees before the gaps appear. An example is shown between the 200 and 300 feet marks on the transect in Fig. 1.9. Generally the effective size of gaps is so small that groups of saplings of the understory species do not occur and such gaps have not been and are not likely to be favourable for the establishment of eucalypts. For eucalypts

1. the gaps are too small (Part Three - Gap Experiment)

2. undisturbed Aoo and Ao horizons are not good seed-beds. (Part Three - Condition of the seed-bed)
3. there is not likely to be any seed as many gaps are caused by the falling of dead trees which have long since shed their last crop of seed and it is very unlikely that eucalypt seed is stored in the surface soil in small gaps for more than a few months. (Part Three - Germinations in the field)

Holloway (1954) describes forests in the South Island of New Zealand which contain very old matai (Podocarpus spicatus). He is of the opinion that the failure of matai to regenerate is due to an adverse climatic change during the life of the ancient matai. This is not the case with eucalypts in the mixed forests of the high rainfall areas of Tasmania, as eucalypt regeneration can be obtained naturally or artificially on areas which carry scattered ancient eucalypts provided the canopy of the understory is sufficiently disturbed.

(iv) Longevity of seed of *Acacia dealbata*

When mixed forest is disturbed *Acacia dealbata* seedlings appear in large numbers. Numerous observations and ring counts have shown that the species does not survive beyond the generation which appears after disturbance of the site and that few trees live for more than 70 years. In forest which has not been disturbed for 350-500 years, *Acacia dealbata* seedlings appear as soon as the stand is opened up and the appearance is so immediate and general

over large areas that the only reasonable explanation is that the seed has remained viable in or on the surface soil for 300-400 years. It appears unlikely that birds etc. could carry sufficient seed in.

It is to be noted that burning is not essential for regeneration of Acacia dealbata, as seedlings appear on all roadsides and logging tracks in mixed forest whether the surrounding forest is burnt or not. Only a minor disturbance of the site is needed to allow the seed to germinate, seedlings appearing in the disturbed soil around the butts of single upturned trees in virgin forest. However such seedlings soon die. Rotten eucalypt logs can be found in some of the temperate rain-forest in the Florentine estimated not to have been burnt for 500 years, yet Acacia seedlings appear when such stands are disturbed; however, in very low numbers compared with mixed forest. The rate of seed-depletion and the limits of viability are not known.

3. CLIMAX TEMPERATE RAINFOREST

(1) Attainment of climax

The climax condition is reached on the death from old age of the generation of eucalypts which arose from the last disturbance of the site (Figs. 1.16 and 1.17). In the past this has meant freedom from fires during the life of the eucalypts. Logging operations now constitute a significant factor of disturbance but as already noted differ in important respects from disturbance by wild fire.

In some areas of rainforest no signs of eucalypts could be found despite a search which included digging into long mounds suggestive of the presence of ancient logs. It could not be deduced whether these areas were likely to have carried eucalypts in the last few thousand years.

(ii) Effect of fire in rainforest

In mixed forest eucalypt seed is not stored on the soil surface for more than a few months (Part Three - Germinations in the field), so once the climax condition is reached on more than a few acres the area, if disturbed, will revert to mixed forests only on its margins i.e. within the range of eucalypt seed-throw. This is uncertain beyond a distance equal to the height of the seed trees (Jacobs 1955) (Gilbert - this thesis). Rainforest species germinate freely immediately after fire and do not need a canopy of Eucalyptus or Acacia for protection during their early growth. The seedlings grow slowly and at the end of the second year only a few are more than a few inches high; with large numbers 1/4 - 1/2 ins. high. It is inevitable that fireweed species will overtop such slow growing plants. There is no evidence that the fireweeds are needed as a nurse. Nothofagus and Atherosperma grow

FIG. 1.16

- (a) Dead eucalypt, from which the top had fallen, standing above rainforest. Atherosperma moschata (foreground) and Nothofagus cunninghamii. Eucalypt not killed by fire. Nothofagus in the stand c.400 years old. Road 7A, Florentine Valley.
- (b) Eucalypt log on the ground in pure rainforest. Nothofagus trees in the stand are up to c.450 years old. Leaves are of Atherosperma moschata. Road 7, Florentine Valley.

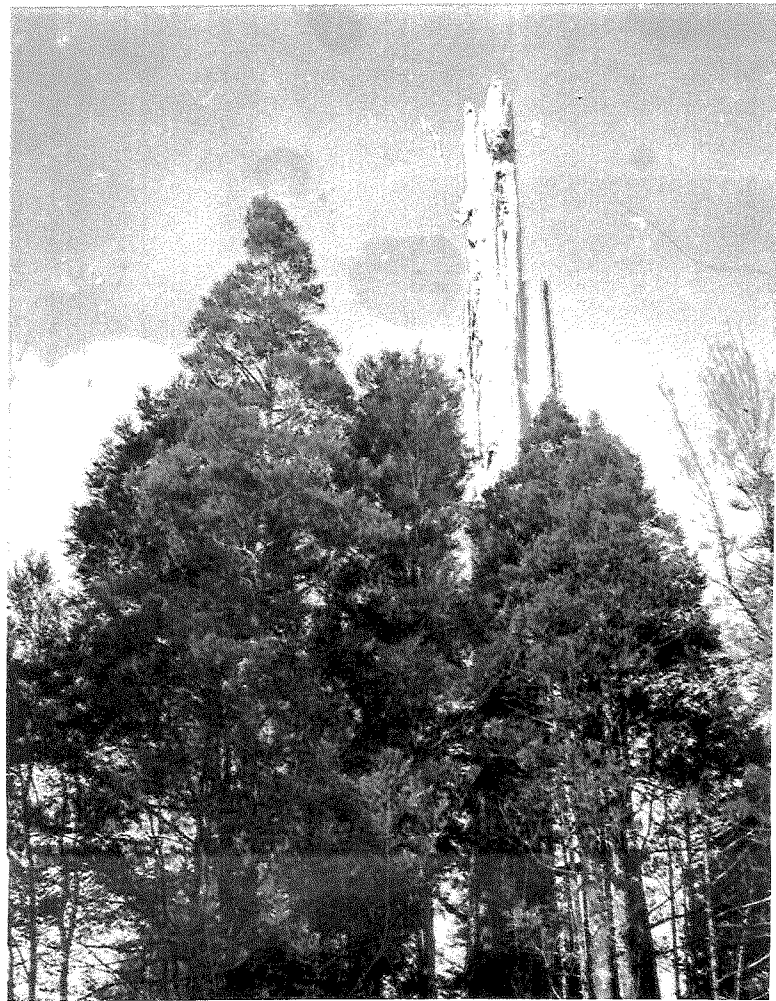


FIG. 1.17

Atherosperma moschata growing
on log of Eucalyptus regnans.
The young roots made their
way down beneath a covering
of mosses or litter. In 150
year old mixed forest.
Lord's block, Florentine
Valley.



faster on open roadsides and on the large bare areas at log marshalling and loading points than in competition with fireweeds. Nothofagus cunninghamii is not a "tender" species as it grows on a wide range of sites in Tasmania from near sea-level to 4000' where it is subjected to heavy snow. In the higher rainfall areas of western Tasmania it will grow on shallow, siliceous soils irrespective of aspect (Jackson 1958).

Frazer and Vickery (1937) reported that when the Eucalyptus seed-trees were removed from around small patches of sub-tropical rainforest in the Barrington Tops district and the small patches later burnt there was immediate regeneration to rainforest. Normally destruction of tropical and sub-tropical forest is followed by a sere from which the climax forest-species are at first absent. There are no comparable seral stages for temperate rainforest in Tasmania. There may be an early development of an apparently unispecific stage but close observation shows that generally all the rainforest species are present.

(iii) Ecological status of Atherosperma

The ecological status of Atherosperma is not clear. In most rainforest and mixed stands it is associated with Nothofagus and on good sites grows to 90-100 ft. compared with 110-120 ft. for Nothofagus. Atherosperma undergoes continuous regeneration by seedlings as well as vegetatively and in terms of recruits to the upper-size classes is usually at a marked advantage compared with Nothofagus. It is more tolerant of low light intensities, has a much wider range of seed dispersal (the seeds float like thistle down) and from general observation would appear to tolerate much wetter conditions in the cotyledon and small seedling stage.

Outside the study area there are fairly extensive areas of mixed forest (with regnans) in which the understory is essentially pure Atherosperma while there are smaller areas where the species forms pure stands. Occasionally very large Acacia dealbata occur in association with Atherosperma in these areas, indicating that poor drainage is not the factor which has favoured the formation of the pure stands. Such pure stands are neither particularly sheltered nor excessively exposed and at the same time the macroscopic features of the soil-profile match those in the adjoining mixed forest.

The course of the development of fairly extensive areas of mixed forest having an understory of pure Atherosperma (which, if there were no disturbance of the site, could lead to areas of pure Atherosperma) is not known. It was once thought that given a long period without disturbance its comparatively superior capacity to regenerate would allow Atherosperma to capture rain-forest sites from Nothofagus. However the frequent association of regnans with pure Atherosperma shows that disturbances which have been frequent enough to perpetuate regnans have not prevented the development of an understory of pure Atherosperma.

Atherosperma has a far greater range of seed-dispersal than Nothofagus, so should seed of Nothofagus not be available in a burnt area, Atherosperma is at a marked advantage (as when for example all seed is destroyed, ^{there is} a poor seed crop or a second fire occurs before the regeneration from the first has produced seed). A stand of Nothofagus probably produces a reasonable quantity of seed each year; the seed begins to be shed

early in February, is shed in large quantities until the end of April, in smaller quantities until about the middle of September and then in very small amounts until the following February. Poole (1950) has reported that the seed of New Zealand species of Nothofagus is ripe during the winter after flowering and is nearly all shed from the cupule shortly afterwards.

The rate of spread of rainforest has not been studied.

The presence of Acacia dealbata in mixed forest is indicative of a disturbance of the canopy of the understory during the previous 50-70 years, and if the forest has not been logged this usually means disturbance by fire. In the areas of pure Atherosperma a few very large Acacia dealbata are to be found, associated with small patches in which Atherosperma has died out through failure to regenerate. In spite of the large quantities of seed which have been shed into these gaps each year, seedlings (even at cotyledon stage) can usually be found only on a few Dicksonia trunks. There is virtually no litter on the ground and there are no traces of recent fire. In pure stands the ground is partly covered with a mat of Atherosperma roots, while the canopy may become so complete that many Dicksonia die because of the small amount of light getting through.

Toxic material leached from the leaves or exuded from the roots of Atherosperma may be a factor which

gives Atherosperma an advantage over other understory species. In addition, in pure stands such toxicity could be involved in the apparent instability of Atherosperma. In the Derwent and Huon River systems Atherosperma generally shows a regenerative advantage over Nothofagus and yet understories or stands of pure Atherosperma are much less common than stands of mixed Nothofagus-Atherosperma. Experimental evidence is required on these points.

VII. COMPARISONS WITH OTHER FORESTS

1. TEMPERATE RAINFOREST AND MIXED FOREST WITH AN UNDERSTORY OF TEMPERATE RAINFOREST SPECIES.

(1) Tasmania

Mixed forest is common in Tasmania where the annual rainfall is more than 50". On good soils the eucalypts in the mixture are regnans, obliqua and gigantea but as rainfall increases, simmondsii and ovata may occur instead, because rainforest species can spread on to the poorer soils occupied by these two species. At elevations above 2500' coccifera, urnigera, gunnii and subcrenulata may be components of mixed forest. Gigantea is present on stabilized talus slopes in western mountains where the rainfall may exceed 80 ins. per annum.

As a general statement it can be said that in mixed forests in Tasmania the eucalypts in any one stand are even-aged and that their continued existence has depended upon periodic destruction of the stand by fire. Eucalypt regeneration cannot become established unless the understory is more or less completely removed.

Some areas of mixed forest in the Arve Valley (for location see Fig.1) show much more disturbance of the canopy of the understory of rainforest species than is the case in the Florentine. Gaps caused by falling eucalypts are more numerous and larger, and as a consequence groups of poles of the rainforest species are common. Eucalypt regeneration is absent.

In Tasmania as mean annual rainfall increases, fire frequency decreases. Towards the West Coast,

rainforest is able to spread on to poorer soils, although the trend is halted in many places where large areas of inflammable sedgeland occur on very infertile, acid soils (Jackson 1958).

In areas receiving less than 50-55 ins. rainfall annually, rainforest tends to be confined to gullies and S.E. facing slopes. Below 35-40 ins. rainforest is rarely found outside steep-sided gullies facing S.E. and in these cases it is doubtful whether the rainforest would spread to drier slopes even if fires were completely excluded. In the 40-50 in. rainfall belt, fires have been frequent enough to maintain an understory of Acacia dealbata, A.melanoxydon, A.verniciflua, Pomaderris, Olearia and Prostanthera lasiantha to name the more common understory species. The extent to which rainforest could spread in this belt, given a greatly reduced fire-frequency, is not clear since edaphic factors become limiting and the necessary reduction in fire-frequency would occur only if there were a substantial change in climate or man were excluded. As a result of the fire-frequency of the last few centuries pure rainforest is rare in the 35-40 in. belt and species such as Eucalyptus regnans are confined to the moister slopes in stands which do not attain the ages of those in old mixed forests with higher rainfall.

(11) Victoria

Temperate rainforest and mixed-forest are developed only to a limited extent in Victoria. Temperate rainforest is confined to very favourable sites - S.E. facing gullies and upper slopes, and mixed-forest occurs as a narrow fringe to these restricted areas of rainforest.

Patton (1955) describes the Victorian fern gully as true temperate rainforest with Acacia melanoxylon, A. decurrens, Lomatia fraseri, Atherosperma, Nothofagus in the upper stratum and Olearia, Bedfordia, Prostanthera, Xieria and Pomaderris in the second story. Such a forest should be regarded as seral with Nothofagus and Atherosperma the only climax species. The limited extent of true temperate rainforest in Victoria compared with Tasmania would appear to be due to hotter and drier summer-conditions which make it difficult for rainforest to exist on N.W. slopes. Also the more frequently occurring extreme fire-danger would enable fires to burn on S.E. slopes where rainforest and mixed forest might otherwise develop. Bad fires have been frequent since white settlement at Melbourne in 1835. Fergusson and Chinner (1955) list 1902, 1919, 1926, 1932 and 1939 as years in which forest fires caused "great damage including serious loss of life", although vast areas of virgin regnans forest escaped destruction until the last of these fires in 1939.

But devastating forest-fires did occur before white settlement and gave rise to extensive even-aged stands of regnans. Patton (1930) dismissed pre-white man fires as a factor which had any effect on present associations partly on the assumption current at the time that regnans reached an age of several thousand years and being a fire sensitive species could not have survived if fires had been frequent. However it is now known that few regnans are likely to be more than 400 years old. In the head of the Ada River (Powell Town district of Victoria) pure rainforest is confined to a very small area along the creeks. A narrow band of mixed forest occurs and extending beyond this for several chains are coppice shoots of Nothofagus from trees burnt in 1939. This fire went through a

small part of the c.165 year-old stand of regnans without killing it. No really old regnans are to be seen even near the creeks but a few 250? year-old trees are scattered through the otherwise even-aged 165 year-old stand, little of which completely escaped the fires of 1939.

There is little doubt that white man's more intensive use of the land has been the cause of an increased fire-frequency in some areas. In the Otways white man's clearing and burning have caused major changes. Carron and Hall (1954) stated that beech (Nothofagus cunninghamii), from which the township of Beech Forest derives its name, was practically extinct in this area.

(iii) New South Wales and Queensland

Nothofagus moorei

Frazer and Vickery (1938) have described the simple structure of Nothofagus moorei forest in New South Wales. The inability of Eucalyptus to regenerate beneath Nothofagus was noted and the presence of old eucalypts among Nothofagus was taken as an indication of the advance of the rainforest species. Disturbance by fire would also account for the continued existence of the eucalypts in the mixture but the frequency of fires would need to have been low in order to ensure that Nothofagus was not wiped out. If fires are frequent rainforest species would only make relatively short-term advances into adjoining eucalypt forest and there will be a repeated sequence of advance and destruction. Vegetation illustrated in Frazer and Vickery's 1938 paper appear to be typical of fire edges (Figs. 44, 45, 46, 47 and plate XII). In one of these (Fig.47) the butt of a tree shows the partial healing of successive fire-wounds and the ground cover of

Poa caespitosa also indicates repeated burning.

Herbert (1936) pointed out that the success of the advance of Nothofagus moorei into eucalypt forest in S.E. Queensland depended upon freedom from fire until Nothofagus had formed a closed community.

2. MIXED FOREST WITH UNDERSTORY OF SUB-TROPICAL RAINFOREST SPECIES.

The mixed forests of Tasmania have a very close counterpart in New South Wales and Queensland where species such as Eucalyptus grandis, microcorys, pilularis, saligna and Tristania conferta have been maintained in mixtures with species of the sub-tropical rainforest by past fires. Swain (1928) writing of Queensland said "In his time the Queensland aborigine scorning Mahomet, persuaded the game to come to him, by applying his fire-stick in the springtime to the production of new hunting-grounds baited with grass fresh-shooting from the ashes. The Queensland cattlemen of today, perceiving the Eucalyptus forest forever asserting itself by bark-fall and leaf-fall and twig-fall and shade of canopy against the permanency of his pasturages, takes side with fire against the forests of the coastal hills, to arrest the silvical succession which otherwise and in so far as site factors permit, would develop through Brush Box (Tristania conferta) and Rose Walnut (Endiandra sieberi) into Araucarian jungle..... On the slopes Eucalyptus pilularis has an advantage over the tenderer jungle trees in its greater hardihood and this advantage is made binding by the incidence of bush fires. By these means it stays the development of the succession and establishes itself as a fire subserer of some stability, itself

regenerating strongly from the ashes of the bush fires which have eliminated its competitors".

Webb (1956) and Baur (1957) also discussed the part played by fire in maintaining mixed forests, where the understories of rainforest species have completely excluded eucalypt regeneration. Nevertheless several authors look to edaphic factors to explain the composition of mixed-forests (McLackie and Petrie (1927), Frazer and Vickery (1938) and Burges and Johnston (1953)).

Mixed forest in high rainfall in temperate and sub-tropical Australia apparently has no widespread counterpart in the tropics. Richards (1952) suggests that the Eucalyptus deglupta communities in New Britain have depended for their existence on past fires but in Africa, as in New Guinea and elsewhere, the rainforest passes abruptly into grassland or savannah which is burnt very frequently - Eggeling (1947), Jackson (1956), Morrison et al (1948), Richards (1952), Thomas (1945). On the highlands of Tasmania and eastern Australia fires have played a part in the origin and maintenance of small Poa caespitosa plains in rainforest on basaltic soils - Herbert (1938), Baur (1957). Natural re-forestation of such openings is slowed by frost.

Similarly on the Pacific coast of North America, fire has prevented the attainment of climax status for certain mixed Pseudotsuga - Tsuga forests (Allen (1954), Hansen (1950), Lindsay (1932)). In south-eastern U.S.A. fires have maintained Pinus spp. in mixed stands with Quercus and Hicoria (Barrett 1943).

PART TWO

FLOWERING AND SEEDING

OF

EUCALYPTUS REGNANS

FLOWERING AND SEEDING OF EUCALYPTUS REGNANS

1. PATTERN OF THE SEASONAL DEVELOPMENT OF BUDS, FLOWERS, FRUIT AND SEED.

For E.regnans, Ashton (1956) has shown that the development of the inflorescence takes about three years. Development commences with the formation of the inflorescence buds in the leaf axils during the summer. The individual buds burst out a year later and flower at the end of another year.

The seed becomes viable before the end of the year in which flowering occurs but at this stage the capsule shrivels on being dried and the seed is not shed. However, by January or February the valves open if the capsule is dried and the seed will be shed.

Periodic inspections of four trees of regnans showed that a similar pattern existed near Maydena. With the pattern established, it was possible to check on the seasonal development of the inflorescence in other areas by inspection of the heads of trees on coupes of known felling date. About fifty coupes were inspected and the information obtained, together with that from the four standing trees, is the basis for the diagrammatic representation of the seasonal development of the inflorescence which follows.

Seasonal development of the inflorescence of E. regnans.

	Year 1	Year 2	Year 3	Year 4
Jan.		- .	*	-
Feb.		- .	*	-
Mar.	Inflores-	Individ-	* - Flowers	- Viable
Apr.	cence	ual	* -	- seed
May	buds.	flower	* -	-
June		buds.	* -	-
July			* -	-
Aug.			* - Ripening	-
Sept.			- capsules	-
Oct.			-	-
Nov.	- .	.	-	-
Dec.	- .	.	-	-

The period of about three years, which elapses from the time of the appearance of the inflorescence buds to the time when the capsule will open on being dried and seed shed, is made up as follows:-

Inflorescence buds	9 - 10 months
Individual flower buds	15 - 16 months
Ripening capsules	8 - 9 months

Ashton (1956) and Cunningham (1957) give photos showing these developmental stages.

The rate of loss of ripe capsules usually increases rapidly three years after flowering. This means that two crops of mature seed are together on the tree for a short while only in the case of trees flowering biennially and for a year in the case of trees which flower annually. Annual crops of seed are usually lighter than those produced biennially.

A pattern of the same general kind was found to exist with obliqua, gigantea and salicifolia but timing varies e.g. flowering of obliqua is usually completed by the end of February. A similar pattern was reported by Fielding (1956) for gigantea, fastigata and pauciflora in the Australian Capital Territory and by Cunningham (1957) for regnans in Victoria.

II. FREQUENCY OF FLOWERING

(1) Data from coupes of known felling date.

With the pattern of the development of the inflorescence determined it was possible to decide the years of flowering on coupes for which the time of felling was known. On the branch, the year of flowering of capsules up to one year old can be decided with certainty, from one to two years old with reasonable certainty, but with less and less certainty thereafter. In very few cases was it not possible to decide the year in which flowering of inflorescence buds and individual flower buds would have occurred. Thus on any coupe there was a possibility of being able to determine the occurrence of flowering over four years - for two years before and two years after the time of felling.

In the Florentine and upper Styx valleys, forty-five coupes were examined, covering fellings from 1953 to the beginning of 1956 and fairly certain observations on the years and intensities of flowering were made for the period 1952-57. There was every possible variation from tree to tree but usually the general position was clear. The result of the examinations is shown in Table 2.1

TABLE 2.1 Patterns of flowering of E. regnans on 45 coupes in the Florentine and Styx Valleys.

Flowering Pattern:	1952/54/56	1953/55/57	Annual	Poor
No. of Coupes:	29	2	11	3
% of Total:	64%	4%	25%	7%

Excluding the coupes on which flowering had been poor, good flowering had occurred biennially in 75% of the cases, although a few flowers had appeared on most trees in all years.

In the regnans forests which were investigated, the 1952/54/56 pattern was found in stands of different ages and there is evidence, which will be given later, that flowering in the even years was general in Tasmania for many years before 1952. It is reasonable to postulate that the maintenance of a biennial flowering pattern is due to a rhythm of physiological processes within the tree, but for stands of different ages in different localities to have the same flowering years it is necessary to invoke some influence outside the tree, such as climatic or biological controls, which bring such stands into coincident flowering.

Attacks by Chrysomelids on at least several hundred acres in the Florentine Valley in the beginning of 1956 caused a change in the 1954/56/58 flowering rhythm. The beetles chewed off most of the growing tips of the eucalypts and in the axils of the leaves were the very young inflorescence buds from which were to come the flowers for the 1958 season. New leafy shoots appeared on the chewed twigs and on these, in 1957, appeared inflorescence buds which would flower in 1959. Trees which had a 1953/55/57 pattern of flowering were not greatly affected as the youngest inflorescence components, at the beginning of 1956, were flower buds on shoots a year old and so less likely to be chewed.

Alternate good and poor flowering years are well known in other trees and some of the causes of breaks in rhythm have been investigated. Tung was regarded as being prone to have good crops only every second year but Laycock and

Foster (1955), over a 10-year period, found a reasonable correlation between the rainfall for the three months when tung flower primordia were being formed and the crop of fruit harvested 9-12 months later. A good crop in 1954 was followed by another good one in 1955 because of good rains at the right time in 1954.

Martin (1956) stated that a biennial rhythm in apple crops is usual. The differentiation of fruit buds occurs 3-4 months after blossoming for the current crop and it is thought that the heavy blossoming and setting of the heavy crop year, reduces bud differentiation, in that year, for next year's flowers. Experiments have shown that if flowers are thinned in the heavy crop year, increased flowering is obtained in the light crop year. Similarly, Ljenes (1951) found the biennial rhythm in Gravensteins was broken by adverse conditions for fruit set in the good year (frost damage to flowers and the prevention of pollination by rain).

The biennial rhythm in regnans cannot arise in the same way because the inflorescence buds for the next good year appear at the same time as the flowers of a current good year. All we have to assume is that there is competition between bud development and fruit development but not between initiation of flowers and fruit development. Also once the inflorescence buds have appeared the potential number of flowers for two years hence cannot be increased e.g. when the Chrysomelids stripped trees of their inflorescence buds at the beginning of 1956, flowering could not occur on these trees until 1959, from buds appearing early in 1957.

The years 1952, 1954 and 1956 were good flowering

years in the Florentine and adjoining valleys but large numbers of inflorescence buds were produced in these years. However, it is possible that the biennial rhythm could be changed from say the odd years (1949/51/53) to the even years by the number of inflorescence buds being considerably reduced in a year in which flowering was extremely heavy and then increased in the next year - normally an off season. Such a break in rhythm is likely to be caused by a major departure from normal climatic conditions - a change which could be expected to bring stands of different ages into coincident flowering.

(2) Data from Victoria.

Galbraith (1937) suggested that abundant flowering occurred every four years on regnans in Victoria. Ashton (1956) said this was substantiated by observations at Wallaby Creek between 1949 and 1956 although his assessments indicate that a biennial rhythm also exists. His assessments of the abundance of flowers were:-

<u>1949</u> moderate	<u>1951</u> poor	<u>1953</u> very poor	<u>1955</u> very poor
<u>1950</u> very good	<u>1952</u> moderate	<u>1954</u> excellent	<u>1956</u> moderate

Cunningham (1957) reported mainly biennial flowering in the Powelltown district.

(3) Data from herbarium specimens.

Twenty-two specimens were available in the Botany Department of the University of Tasmania and of these fifteen had been collected between 1937 and 1953 from northern, north-eastern, central and southern Tasmania. Of these fifteen specimens, thirteen showed that flowering had or would have occurred in the even years (1936, 38....or 54) and in eleven

cases flowering was in alternate years. This was strong evidence that biennial flowering, in the even years, had persisted in Tasmania since about 1936 at least and was fairly general. No inference could be drawn from the seven specimens collected between 1899 and 1925.

Specimens in the National Herbarium, Melbourne, were examined but of the nineteen available, nine were not dated and the remaining ten were spread over the period 1867-1949.

III. VIABILITY OF SEED

Number of viable seeds per pound.

Specifications.

Once seed has been extracted from the capsules it is usual practice to sieve off the capsules and leafy and twiggy material. Then dust and other fine material is sieved off leaving a residue of seed in which the amount of foreign matter depends on the care and frequency of sieving. The proportion of viable seed to chaff (partly developed and unfertilized ovules) which can be obtained by sieving depends on the species of Eucalyptus being dealt with. All the Tasmanian species in the section Renantherae, which includes regnans, have a high proportion of the chaff with a particle size equal to that of the viable seed, whereas in the Macrantherae species looked at (globulus, gunnii, virginialis, subcrenulata, johnstoni) the viable seeds are much larger than the chaff and can be separated out by sieving.

Thus there is need to specify the sieves used to obtain the seed aggregate for which estimates of seeds per pound are given. In the Renantherae the numerical proportion of viable seed may be low - about 10% in regnans - but as the viable seed cannot be separated mechanically and much cannot be distinguished by eye, it requires a cutting test or germination test before an estimate of the number of sound or viable seed per pound (of material sieved to a certain specification) can be given.

After trials with several lots of seed, it was found that all seed of regnans except an occasional very large one, would pass through a sieve with an aperture of

1.405 m.m. and that a sieve with an aperture of 0.422 m.m. retained all viable seed. Only a few pieces of chaff passed through this sieve but when the next largest available one was tried (0.599 m.m.) the smaller viable seeds were lost.

All statements made in this thesis regarding the number of seeds or germinations per pound of regnans seed, are based on material passing through a 1.405 m.m. sieve and caught on a 0.422 m.m. sieve.

The total number of seed per pound and the number of viable seed per pound varies greatly in regnans from one collection to another. The means of small sample counts of different lots of seed showed a range of 1,040,000 - 1,230,000 seeds per pound and the number of viable seed per pound, from germination plus cutting tests, varied from 115,000 - 165,000. For the few trials made, seed from young trees (25-30 years) gave more germinations per pound than seed from old trees (200 plus years).

The results of germination tests in the laboratory are shown in Table 2.2.

TABLE 2.2

The number of germinations per pound of
Eucalyptus regnans seed collected in the
Maydens district.

SOURCE OF SEED	DATE		GERMIN- ATIONS PER POUND.	REMARKS
	Col- lected	Tested		
1. Young trees	Jan. '55	Sep. '55	90,600	Test spoiled by fungi
		Apr. '56	157,100	
		Sep. '56	136,000	
		Nov. '57	52,800	
2. Old trees	Jan. '55	Sep. '55	34,300	Test spoiled by fungi
		Apr. '56	61,400	
3. Equal parts 1 & 2	Jan. '55	Apr. '56	109,200	
4. Old trees	Jan. '56	Oct. '56	103,000	
5. Old trees	Jan. '57	Nov. '57	116,000	

IV. THE FALL AND DISSEMINATION OF SEED

1. GENERAL CONSIDERATIONS

Eucalyptus capsules and seed are not winged and fall vertically from the tree, unless the wind is blowing at the time of their fall. In the Florentine the prevailing and strongest winds over the whole year are from the north-west to south-west so that maximum dissemination of seed will be to the east (north-east to south-east).

The total amount of seed which falls depends on the number and quality of seed-trees but the distance of dissemination will depend on the height of the trees, the velocity of the wind as the seed falls and the obstruction of other trees. There is so much variation in the number and quality of seed trees and in the number of obstructing trees that it was decided to get information concerning the maximum amount of seed which falls per unit area (underneath the seed-trees) and the distance to which seed is blown when there are no obstacles. The first investigation could be undertaken readily but the second depended on finding a coupe on which few trees remained standing after logging and on which seed-traps could be arranged away from a suitable edge of trees without contamination by seed of other trees.

2. EXPERIMENTAL PROCEDURE

The amount of seed which falls at any point at any time will be affected by the seasonal pattern of fall and the distance and direction of the point from the source of seed. Even with an edge of seed trees, the amount of seed falling at any point at any time will be affected by

the position of that point in direction parallel to the edge of seed trees as well as distance from the edge. Therefore the fall and dissemination of seed has been measured by:-

- (1) samples taken in time and two-dimensional space by traps moved after each interval of time to new randomly-selected positions; and
- (2) counts of seed, falling into stationary traps beneath the trees of the seed-edge, for the intervals of times between movements of the roving traps.

This procedure was suggested by techniques used by Wilm (1946) in making certain micro-climatic investigations.

For each period of time (2-8 weeks) the ratio was determined of the mean monthly rate to the actual monthly rate of fall of seed into the fixed traps. The actual catch in each roving trap at each randomly selected point in space was then converted to a mean monthly rate for that position on the assumption that for that period of time the ratio of mean catch to actual catch would be the same for the fixed as for the roving traps.

The seed-traps were made of galvanized iron and had a catchment area of $1/4400$ acre. They were funnel-shaped with detachable cups at the bottom - Fig. 2.1. The bottom of the cup was of fine wire mesh which allowed water to drain away but retained all eucalypt seed (including chaff).

3. AREAS ON WHICH INVESTIGATIONS MADE (For locations see Fig. 1.3A)

(1) Road 11, Florentine Valley.

Part of a mixed forest, containing regnans 250' high, and with a crown depth of 100', was logged in January 1956 leaving a S.W.-N.E. edge of eucalypts at the N.W. end of the coupe, rain forest on the

FIG. 2.1

(a) SEED TRAP made of G.I.
with area of catch 9.9 sq.ft.
Detachable cup has a bottom
of wire screen of fine mesh.

(b) LITTER TRAY made of G.I.
with area of catch 10 sq.ft.
Drainage holes in bottom.
In 150 year old mixed forest.
Eucalyptus regnans on right,
Nothofagus cunninghamii on
left. Dicksonia antarctica
in centre.



western side and a previously logged coupe on the eastern side - Fig. 2.2. On the south-eastern side, the coupe was separated from uncut forest by a road. A rectangular plot 250' x 750', was laid out between the N.W. end of the coupe and the road, with the long axis on a bearing of 326°. This plot was divided into three square sub-plots and two roving traps assigned to each while two (later three) traps were placed in fixed positions in the uncut forest.

In this area information was sought on the spread of seed with north-westerly winds. South-easterly to southerly winds are of low strength in the Florentine. High-lead logging had left only a few trees standing in the area of the plot and these were felled before the plots were established.

(11) Lords, Florentine Valley.

In January 1956 only one area was available for investigation of the spread of seed by south-westerly winds. A long edge of regnans trees (bearing 340°) had been left along the western edge of contiguous coupes and a plot, 100' x 300', was put in with the long axis at right-angles to the cutting edge. The plot was divided into three square sub-plots and two roving traps assigned to each. The fixed traps at Road 11 were to be used to give a measure of the variation in the fall of seed with time.

The edge of trees proved to carry much less seed than an inspection of heads had indicated and this plot was abandoned at the end of a year.

(111) Coupe W.48, Florentine Valley.

Coupe W.48 was logged in August 1957 and was the first suitable area, after the plot at Lords proved unsatisfactory, for a study of the spread of seed with westerly winds - Fig 2.3. Three sub-plots, each 125' x 125', were put along a line running at 110° from an edge of regnans trees (230' high, crown depth 90'). The fixed traps at Road 11 were to be used to give the variation in the fall of seed with time.

Sub-plot size was reduced on the Lords and W.48 areas with the object of getting more information



Fig. 2.2. Seed-trapping area Road 11, Florentine Valley, regnans 250 ft. high, are 750ft. from camera. Age 150 years. Understory of Nothofagus cunninghamii & Atherosperma moschata. Logging by high lead, Jan. '56. Photo March '58. Few Dicksonia antarctica amongst Erechthites prenanthoides.



Fig. 2. 3 Seed-trapping area coupe W. 48, Florentine Valley. Eucalyptus regnans, 230ft. high, are 400ft. from camera. Stand lightly burnt in 1934. Understory of Pomaderris apetala with few large Acacia dealbata. Foreground logged by high lead in August '57. Photographed March '58.

in the zone in which it was expected that the rate of fall of seed would rapidly diminish with increasing distance from the seed-trees.

4. SEASONAL PATTERN OF THE FALL OF SEED.

(1) Information on the seasonal pattern of the fall of seed was obtained from two (later three) traps installed in fixed positions under trees in the uncut stands bordering the seed-trap area at Road 11. The data are shown in Table 2.3, with the actual catches converted into rates per month (30 days). The patterns of the rates are shown in Figs. 2.4, 2.5 and 2.6, where the values are referred to the middle of the periods of catch.

The traps are separated sufficiently to make it fairly certain that different trees or groups of trees are concerned with the fall of seed into each trap. While the fall of seed into different traps can be expected to vary during any one interval of time, markedly different trends would indicate that over short periods the amount of seed which will fall may be somewhat fortuitous. The most marked differences in trend were:-

1 May - 31 May 1956. The monthly rate of catch of the north trap increased from 83 to 154 (Fig. 2.4) while that for the south trap decreased from 102 to 33 (Fig. 2.5)

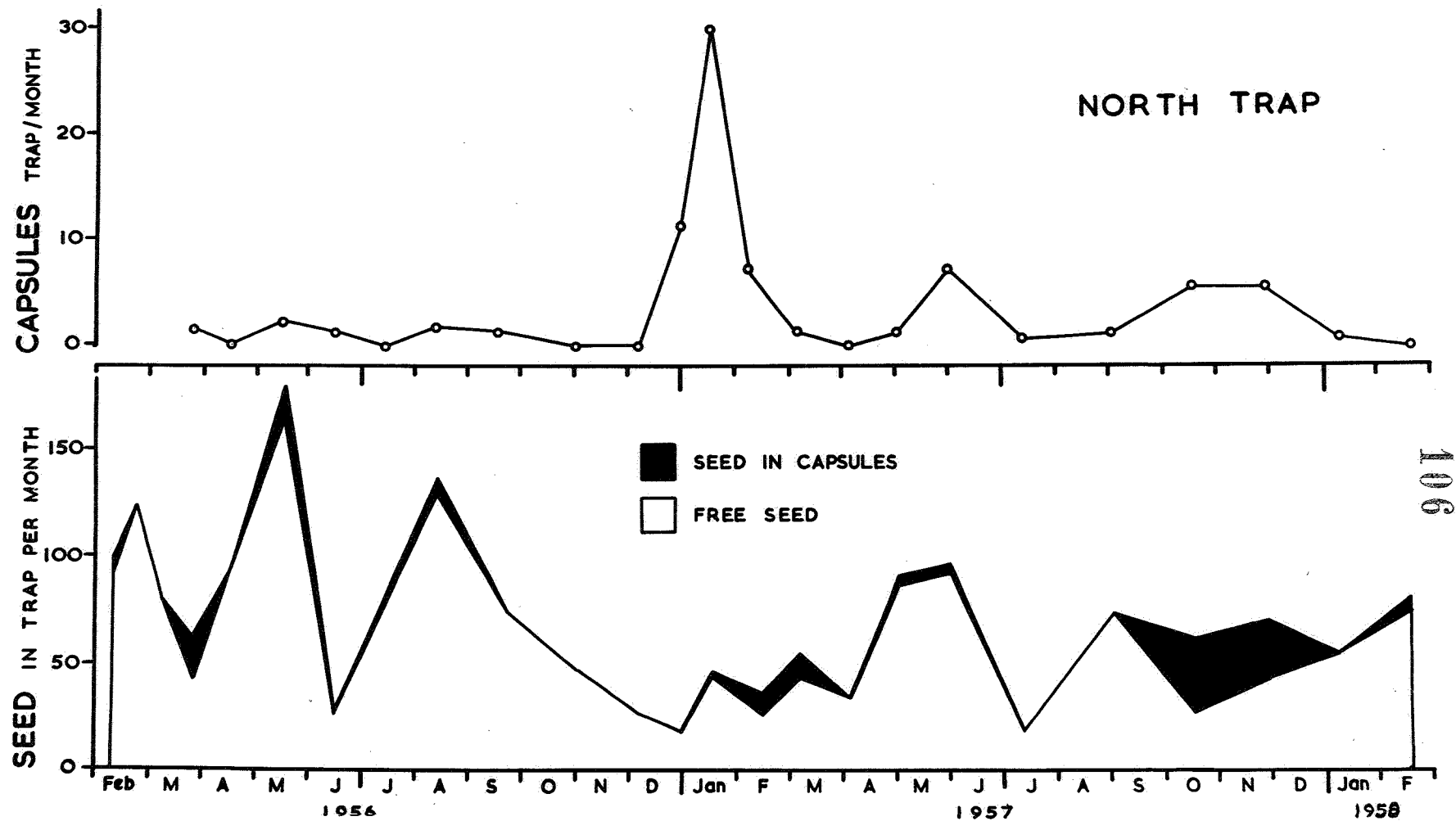


Fig. 2.4. Pattern of the MONTHLY RATE OF FALL OF SEED (sound plus chaff) AND MATURE CAPSULES into fixed trap north. Trap area 1/4400 acre. Seed separated into that which fell in capsules and that which was shed while the capsules were on the tree. Eucalyptus regnans, Road 11 Florentine Valley.

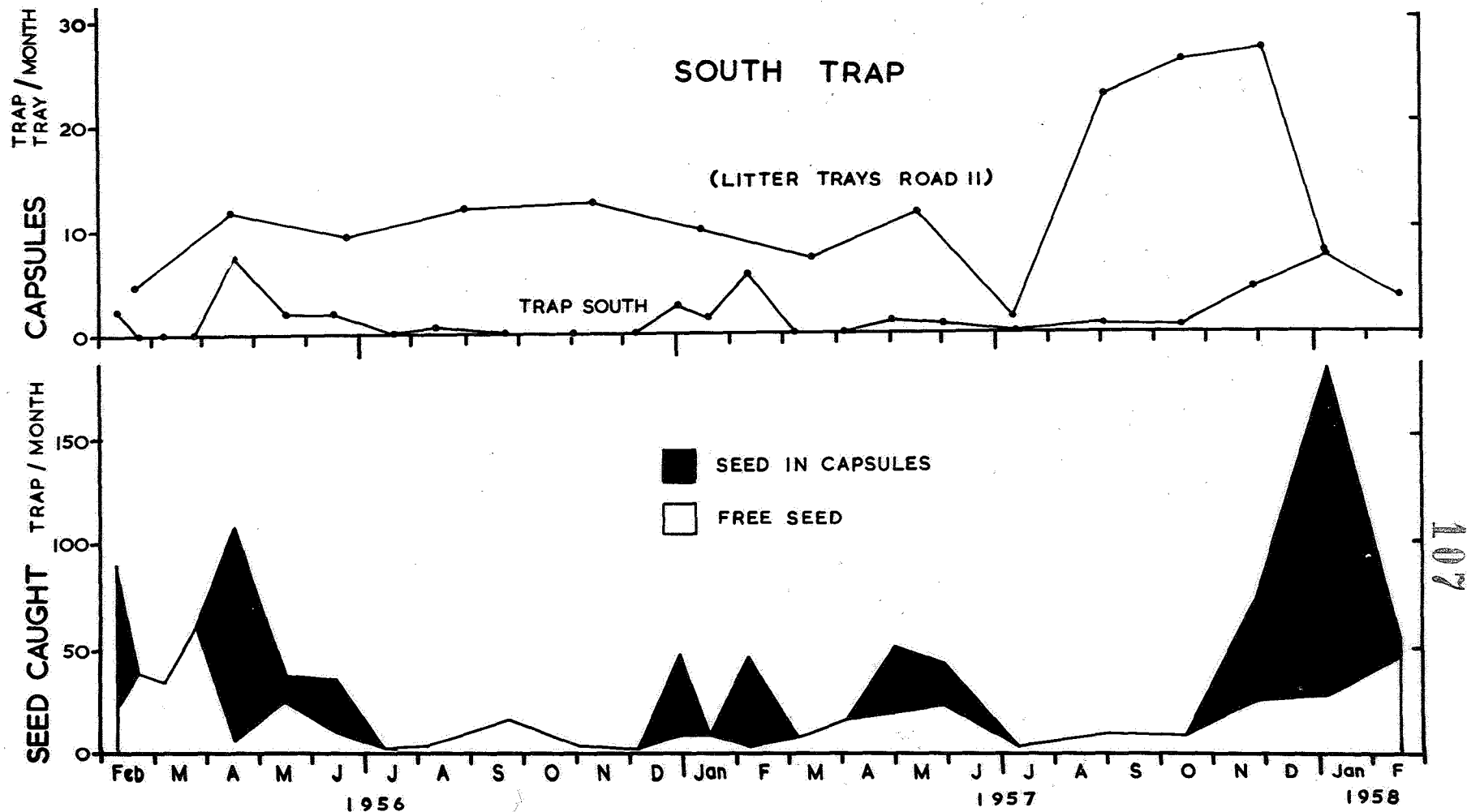


Fig. 2.5. Pattern of the MONTHLY RATE OF FALL OF SEED (sound plus chaff) and MATURE CAPSULES into fixed trap south. Trap area 1/4400 acre. Seed separated into that which fell in capsules and that which was shed while the capsules were on the tree. Also shown is the pattern of the mean monthly rate of fall of mature capsules into three litter trays in a nearby stand. Eucalyptus regnans Road 11, Florentine Valley.

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NORTH-EAST TRAP

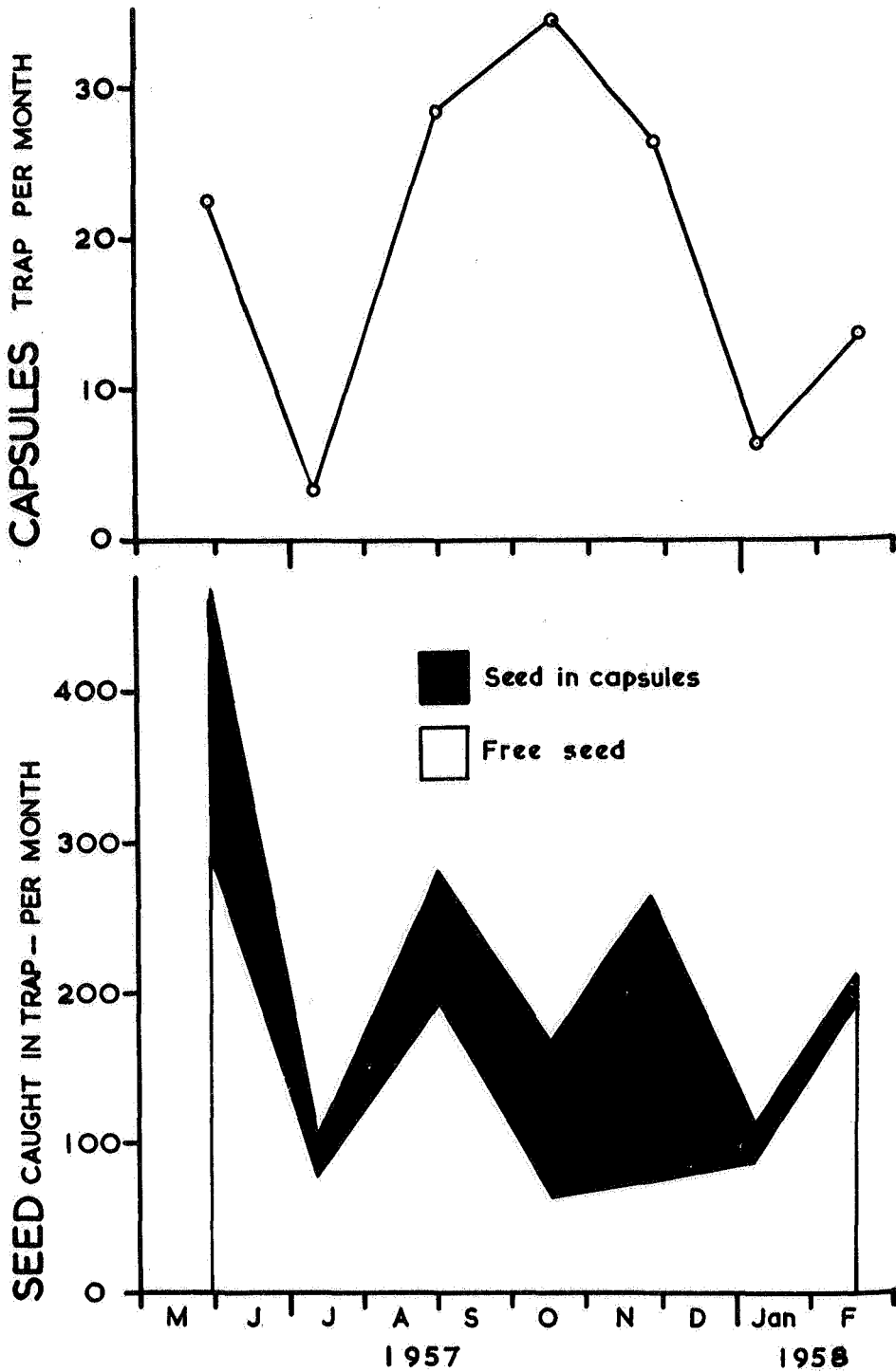


Fig. 2.6. Pattern of MONTHLY RATE OF FALL OF SEED (sound plus chaff) and MATURE CAPSULES into fixed trap northeast. Trap area 1/4400 acre. Seed separated into that which fell in capsules and that which was shed from the tree. E. regnans, Road 11.

16 December - 29 January. The monthly rate of catch of the north trap decreased from 65 to 50 (Fig.2.4) while that of the south trap increased from 71 to 142 (Fig.2.5).

Marked changes in the amount of seed falling in capsules into the south trap were responsible for these divergences.

No clear seasonal pattern of fall was evident in the catches of the north trap (Fig.2.4). The pattern of peaks in May and August 1956 with a low trough in July was repeated, somewhat less strongly, in 1957. In contrast with this suggestion of a recurring seasonal pattern, the lowest rates for the whole period were July '56, December '56 to January '57 and July '57. But the rate for December '57 to January '58 was more than double that for the corresponding period 12 months earlier.

It would be expected that a stand which had flowered well in 1954 and 1956 but very poorly in 1955 and 1957 would have an annual pattern of seed fall, if one existed, superimposed upon a biennial rhythm. The values for the south trap (Fig. 2.5) appear to follow such a trend with peak rates of fall in the summers of 1955/56 and 1957/58, and low to moderate rates during the intervening period.

Figure 2.5 shows the mean number of mature capsules falling per month per tray into three litter trays put out in the stand in which the south trap is exposed. The capsules were mainly from the 1954 crop and the rate of fall was fairly regular from April '56 to May '57. After declining in July the rate increased

to high values during September, October and November. This peak is indicative of the increased rate of fall of capsules which usually occurs $3\frac{1}{2}$ years after flowering and is in keeping with a biennial pattern in the fall of seed. The rate of fall of capsules into the south trap showed annual tendencies.

It is to be noted that there was no season during which some seed did not fall.

(11) Seed falling free and in capsules.

For the period 3/2/56 - 29/1/58, the totals of the actual catches of seed which fell after being shed from capsules on the tree (free seed) and that which fell in capsules, are shown in Table 2.4.

There was great variation from trap to trap (i.e. from one group of trees to another in the one stand) in the percentage of seed which fell in capsules; over a period of two years it was 9% for the north trap and 60% for the south trap. For the north-east trap for the eight months of its operation, 44% of the seed fell in capsules. For all traps the mean was 35%. In the case of the north and south traps the fall of seed in capsules was erratic - see Table 2.3. There was a much higher rate of fall into the north-east trap but there was no consistency between traps as to the times of increased falls of seed in capsules.

From figures given by Cunningham (1957) for fully stocked stands and cut-over areas with a residual of 4-5 seed trees per acre, it can be seen that the seeds which fell in capsules comprised 31-41% of the total for six out of seven locations in Victoria and 79% for the

TABLE 2.4 The total amounts of seed of *E. regnans* which fell into fixed traps, Road 11, Florentine Valley.

Periods of catch:

North & South 3.2.56 - 29.1.58
North-east 16.5.57 - 29.1.58

NORTH TRAP				SOUTH TRAP				NORTH-EAST TRAP			
Free seed		In capsules		Free seed		In capsules		Free seed		In capsules	
T	S	T	S	T	S	T	S	T	S	T	S
1254	147	131	11	315	40	469	78	911	132	706	88
In capsules: 9.4%				59.8%				43.7%			
Sound seed: 11.4%				15.1%				13.6%			

MEANS: Seed falling in capsules 34.5%
 Sound seed 13.1%

T = total number of seed

S = number of sound seed (cutting test)

other. For traps underneath trees at Warrentine (Tan) 55% of the seed caught was in capsules.

(iii) The relation of the fall of capsules to the fall of seed.

(a) North Trap (Fig. 2.4)

Generally, peaks in the rate of fall of seed corresponded with coincident peaks in the rate of fall of mature capsules and as only 9% of the seed fell in capsules, a reasonable conclusion might be that most seed was shed from the capsule shortly before the capsules fell from the tree.

However, the amplitudes of the two sets of peaks do not correspond e.g. in January 1957 the amplitude for capsule-fall is relatively far greater than that for seed-fall, which in fact is below average (43 c.f. average 58).

A few counts of the number of sound seed plus unfertilized ovules in capsules of regnans gave a range of 25-30 per capsule. For the period 16.3.56 - 29.1.57, 32 mature capsules and 635 seed fell into the trap. Without knowing what went before, it is reasonable to assume that the large number of empty capsules which fell in January 1957 had shed their seed over a long period of time; certainly back to July '56 and probably to May '56.

Periodic observations on certain trees showed that some capsules which die and shed their seed may remain on the tree for many months - 5 to 7 is common and one dead capsule remained for at least 17 months. However, the big majority of the capsules fell from the trees during the periods between inspections (periods of 2-3 months) - Table 2.5.

TABLE 2.5 Mature capsules on trees of *E. regnans* and *E. obliqua*, the number which fell and the number of open capsules observed. Maydena.

SPECIES & TREE NO.	YEAR OF FLOWER -ING.	SCORINGS		NO. OF CAPSULES			TOTAL NO OPEN CAP -SULES OBSERVED
		No.	Period	Start	Finish	Fell	
regnans 8/1	1954	10	7/55-12/57	217	91	126	1
" 8/2	"	10	"	94	59	35	9
" 8/2	1955	7	2/56-12/57	231	190	41	10
obliqua 5	1955	10	2/56-12/57	79	33	46	13-20
regnans 1/1	1956	5	3/57-12/57	42	40	2	8
" 1/2	"	5	"	22	19	3	3
" 1/3	"	5	"	35	35	-	-
" 8/1	"	4	"	12	6	6	-

Of the 311 mature 1954 capsules of ragnans which were under observation, 161 fell from the tree but only ten open capsules were observed on the trees. If say 50% of the seed which fell from these trees came from capsules which opened on the trees only 10 of the 80 capsules concerned remained on the trees long enough to be observed at the next time of scoring.

(b) South Trap. (Fig. 2.5)

The time and rate of seed-fall matches the time and rate of capsule-fall but delay is evident in the fall of some capsules which opened on the tree. No open capsules were caught between the end of August '56 and February '57 so the free seed caught in September '56 came from capsules which opened on the tree in September and did not fall until the following February.

Similarly seed which fell in March-April '57 came from capsules which did not fall until May. However, seed-fall generally corresponded with capsule-fall.

(c) North-east Trap. (Fig. 2.6)

The pattern of the rate of fall of seed into this trap was similar to that for the north trap (Fig. 2.4), with peaks in May and August separated by a low trough in July, but the amplitude for the north-east trap was much greater.

For capsules, the pattern of the rate of fall was very similar to that for the trays near the south trap (Fig. 2.5) with the capsules nearly all coming from the 1954 flowering. Most of the seed which fell during the second half of 1957 came from this flowering. Of all the seed caught, 44% was in capsules.

(iv) Absolute amount of seed which fell.

The north, south and north-east traps were set to be assured of good catches, so that reliable estimates the variation in the rate of fall of seed, with time, could be obtained. The rates of catch (Table 2.6) could be expected to be over-estimates for the whole stand.

TABLE 2.6 The rate of catch (per acre per year) of E. regnans seed in three fixed traps. Road 11, Florentine Valley.

Period of catch: North & South Feb. '56 - Jan. '58
North-east Jun. '57 - Jan. '58

	NORTH TRAP	SOUTH TRAP	N.E. TRAP
Length of catch - months	24	24	8
No. of seed - free fall in capsules	2,750,000 288,000	692,000 1,030,000	6,000,000 4,650,000
TOTAL:	3,038,000	1,722,000	10,650,000
No. of sound seed	347,000	259,000	1,450,000
Pounds/ac/year	2.7	1.5	9.3

5. DISSEMINATION OF SEED

(1) Theoretical limits.

The distance from the tree to which eucalypt seed will be blown on being shed from the capsule will depend on the height above ground of the capsule, the terminal velocity of the seed (and hence the time taken by the seed to reach the ground) and the mean velocity of the wind to which the seed is subjected while it is falling.

The time of fall of small quantities of seed of regnans was measured from six different heights in a stair-well. The results are shown in Fig. 2.7 and in spite of a rather crude timing method a very satisfactory time-distance relationship was established. (The time-keeper sat at the bottom of the well alongside a large sheet of paper. The watch was started as the co-operator was seen to tip the seed from a phial and stopped as the seed pattered on the paper).

The terminal velocity was 11.4 ft. per sec. for sound seed and 9.1 for chaff and these rates were reached within 10-15 ft. The mean of eight readings gave a time of 1.025 secs. for the fall of sound seed for 10 ft. from a position of rest. Grose (1955) found the terminal velocity of seed of regnans to be 13 ft. per sec. and that this was reached in the first 15 to 20 ft.

The terminal velocities can be used for the whole distance of fall from capsule to ground and if, in the absence of data, it is assumed that the component due to wind is horizontal and equals the velocity of the wind, a table can be prepared of expected distances of seed dispersal according to the height of the capsule and the mean velocity of the wind.

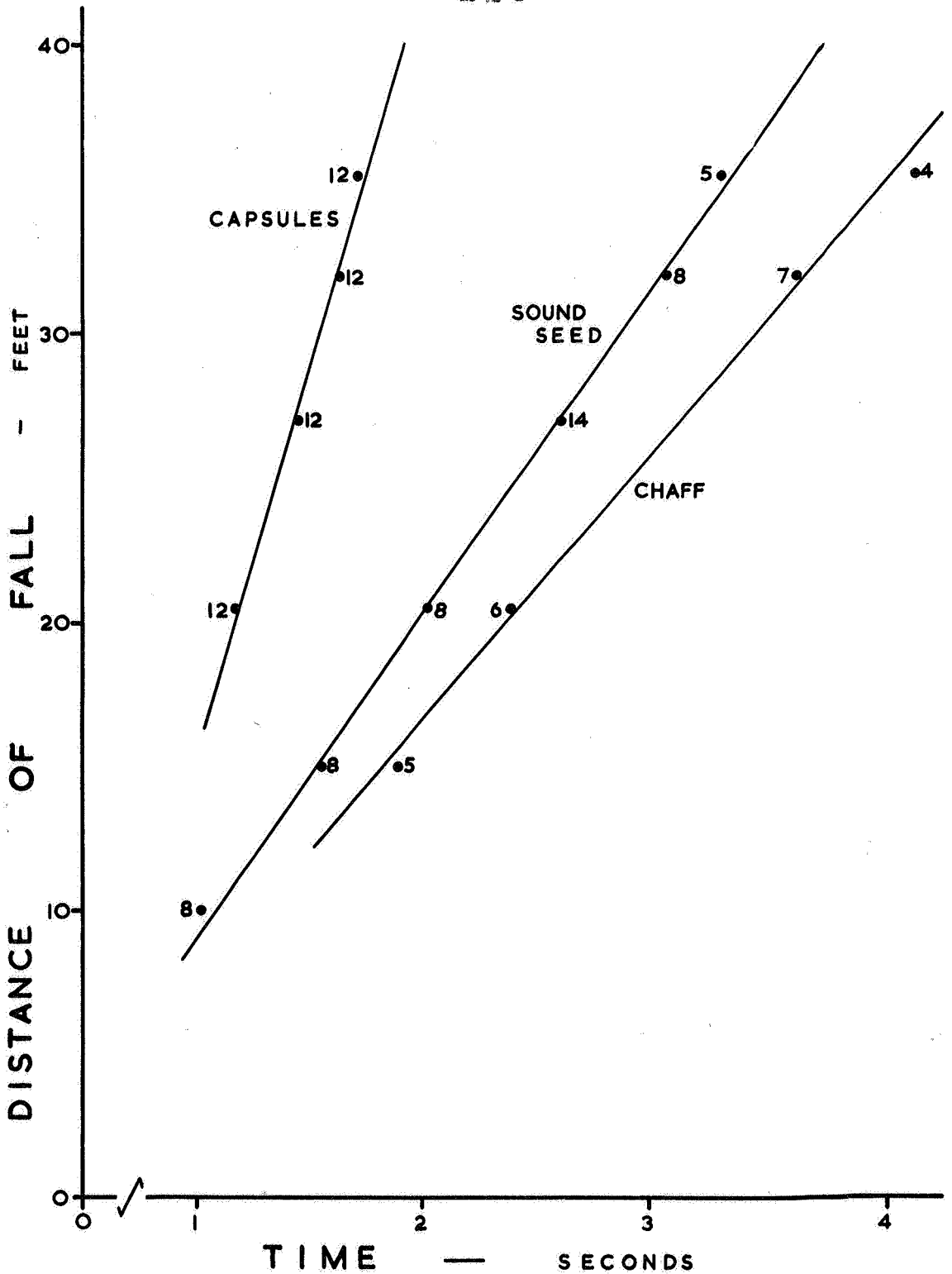


Fig. 2. 7. TIME-DISTANCE RELATIONSHIPS OF seed bearing CAPSULES, sound SEED and CHAFF of *Eucalyptus regnans* measured in still air for falls from a position of rest.

TABLE 2.7 Expected distances (ft.) of dispersal of seed (sound and chaff) of *E. regnans* from capsules at certain heights and with winds of certain velocities.

Terminal velocity of seed + sound 11.4 ft. per sec.
chaff 9.1 ft. per sec.

WIND VELOCITY M.P.H.	HEIGHT (FT) FROM WHICH SEED FALLS									
	50		100		150		200		250	
	S	C	S	C	S	C	S	C	S	C
5	32	40	64	80	95	120	130	160	160	200
10	64	80	130	160	190	240	260	320	320	400
20	130	160	260	320	385	360	515	645	645	805
30	190	240	385	485	580	725	770	965	960	1210

S = Sound seed

C = Chaff

(Part of the data of this table are shown in Fig. 2.8)

No records of wind-speeds are available from which can be taken information such as the relative frequencies of mean wind-speeds for periods of 20 seconds and no investigations have been made into the patterns of wind-velocity in cut-over forests in the Florentine.

The effect of turbulence is not known. Geiger (1950) quoted work by W. Schmidt which showed that with decrease in terminal velocity, the distance to which seed was carried increased with extraordinary rapidity e.g. seed of *Fraxinus* had a terminal velocity of 200 cm/sec. and at least 1% of the seed reached 0.03 k.m., whereas for dandelion seed, with a terminal velocity of 10 cm/sec., the distance was 10 k.m. Seed of *regnans* with a terminal velocity of c. 350 cm/sec would be far less frequently affected by eddies.

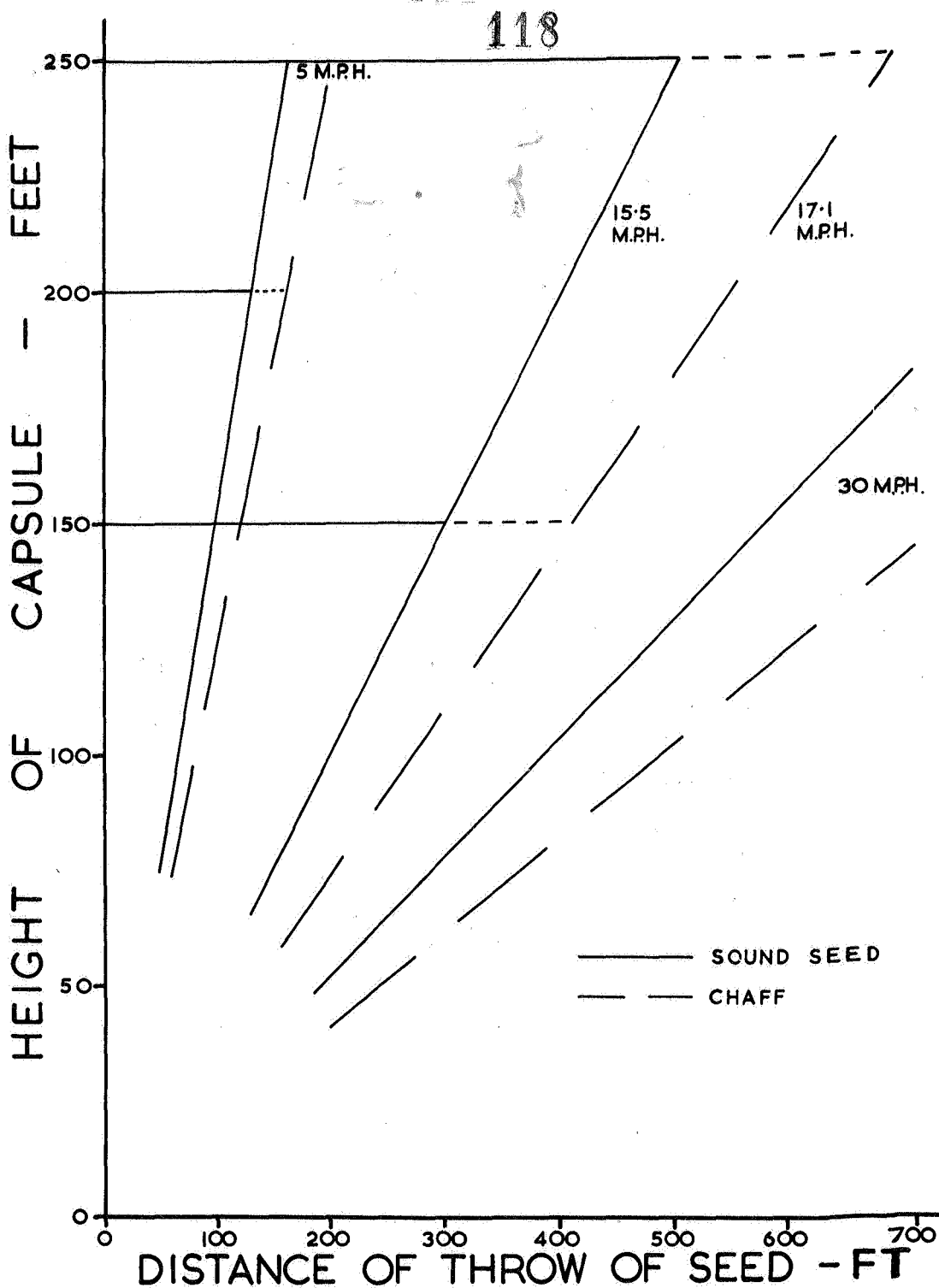


Fig. 2.8. DISPERSAL OF SEED. Theoretical limits to which sound seed and chaff of *Eucalyptus regnans* will be blown from capsules at certain heights, at certain mean wind speeds. Terminal velocity of sound seed 11.4 ft./sec. and of chaff 9.1 ft./sec. For the conditions at Road 11, Florentine Valley, it would appear that sound seed was rarely subjected to mean wind speeds in excess of 15.1 m.p.h. and chaff 17.1 m.p.h. Crowns of trees 100 ft. in depth (150-250 ft.).

The terminal velocities of capsules containing seed were determined for two trees of regnans from Mt. Wellington - one considered to have fruit of average size and another of above average size. The differences between trees in the time of fall from various heights were so small that all values were combined for the purposes of the graph in Fig. 2.7. The terminal velocity was 27.2 ft/sec. and this value was used in compiling Table 2.8.

TABLE 2.8 Expected distances (ft) of dispersal of capsules (containing seed) of *E. regnans* from various heights and with winds of certain velocities.

Terminal velocity of capsules 27.2 ft/sec

WIND VELOCITY M.P.H.	HEIGHT (FT) FROM WHICH CAPSULE FALLS				
	50	100	150	200	250
5	13	27	40	55	65
10	27	55	80	110	135
20	55	110	160	215	270
30	80	160	245	325	405

With a terminal velocity of 27 ft. per second, regnans capsules would be far less frequently affected by turbulence than seed but may be dispersed over long distances when twigs, bearing leaves and capsules, are broken off by strong winds. As Jacobs (1955) pointed out, such dispersal is of interest in connection with the spread of a species but of little account when considering the establishment of a good stocking of regeneration over a short period.

TABLE 2.9

Dissemination of seed of *T. regnans* Road 11, Florentine Valley
 Distances from edge of seed-trees and adjusted rates of fall (trap/month) into roving traps.
 Traps set 3.2.56. FIGURES 2.9 and 2.10.

DATE	NORTH TRAP				ROVING TRAPS											
	Seeds/Trap/ Month		Ratio Mean/ Act. Catch													
	T	S	T	S	D	T	S	D	T	S	D	T	S	D	T	S
1956																
17/2	81.5	17.2	0.7	0.8	95			185			285			425		
1/3	117.7	4.6	0.5		165	4.6		220	1.2		270	2.3		280		
16/3	70.0	8.0	0.8	0.8	-	27	3.2	220	4.9		295			305		
4/4	56.9	3.2	1.0		10	6.3		210			270	1.6		350		
1/5	83.3	8.9	0.7	0.7	170	9.3	1.6	235			255	2.3		355	3.1	
31/5	154.2	25.9	0.4	0.2	10	53	3.1	15	19	2.8	320	0.8		445	0.4	
28/6	24.4	1.1	2.4	5.8	10	99	25	80	32	13	275	5.3		365	13	
26/7	2.2		25.5		145	28		185			285			290		
30/8	128.3	7.1	0.5	0.9	20	69	18	85	41	3.2	315	7.9	0.8	370	5.7	0.8
15/10	66.7	6.7	0.9	1.0	40	5.4	3.2	245			375	0.6		475	0.6	0.6
21/11	39.8	7.3	1.5	0.9	145			210	2.4		295			365	2.4	0.7
20/12	19.7	6.2	3.0	1.0	35	4.3	4.1	135	25	4.1	260			460		
1957																
10/1	15.7	2.9	3.7	2.3	60	5.3		190			275			300		
29/1	42.8	3.2	1.4		145	2.2		195			265			480		
19/2	30.0	5.7	1.9	1.1	65	18	3.2	200	8.2		365			390	22	
26/3	48.5	6.2	1.2	1.0	115	19	3.1	135	1.3		360	1.3	1.0	370		
17/4	30.0	4.4	1.9	1.5	75	13	1.7	125	4.3		270			365		
15/5	81.4	8.6	0.7	0.8	-	126	19	55	12	4.1	260			485	0.8	
13/6	89.9	6.2	0.6	1.0	35	62	12	205	3.7		355	0.6		420		
7/8	18.5	1.1	3.2	5.9	150			185	23	3.2	420			460		
25/9	61.8	11.0	0.9	0.6	15	122	9.3	200	6.1		395	1.1	0.4	470	0.6	
7/11	33.0	7.7	1.1	0.8	75	17	4.1	90	29	3.6	460			485		
16/12	64.7	5.4	0.9	1.2	40	50	4.5	80	14	0.9	270	0.7		365		
1958																
19/1	54.6	4.8	1.2	1.4	-	40	8.6	130	11	1.9	255	2.5		380	0.8	
9/3	74.6	5.4	0.8	1.2	120	4.3	0.9	235	4.3		345	1.2		455		
MEANS	58.0	6.5			STRATUM 1				STRATUM 2				STRATUM 3			

D - Distance (ft) from seeding edge; T - total seeds and S - sound seeds, per trap per month

To convert to rate/acre/month multiply by 4395.6

Thus 30-40% of the seed crop (the proportion falling in capsules) will be scattered over very short distances only.

(11) Investigations by seed trapping.

(a) Road 11, Florentine Valley.

As described earlier, the investigation on this area was designed to give information on the spread of seed with north-westerly winds.

In Table 2.9 rates of fall are given for the total number of seed and the number of sound seed falling into each roving trap, in each of its several positions, per month of 30 days. Each rate has been adjusted according to the ratio of the mean monthly rate of catch of the fixed trap, over 765 days, to the catch for the period concerned.

All Seed. The data for total seed are graphed in Fig. 2.9. Despite great variability in the rate of fall for the first 200 ft. or so from the edge of seed trees, the following points emerged:-

(1) there was a very rapid decline in the rate of fall of seed in the first 150 ft. from the trees. The mean rate of fall into the fixed trap north was 58 seed per month but at 100 ft. from the trees the fall was only a quarter of this rate and at 150 ft., only one-tenth.

(2) a few sporadic catches were made out as far as 600 ft. Beyond this distance the few seeds caught may have come from trees other than those at the north-western end of the area.

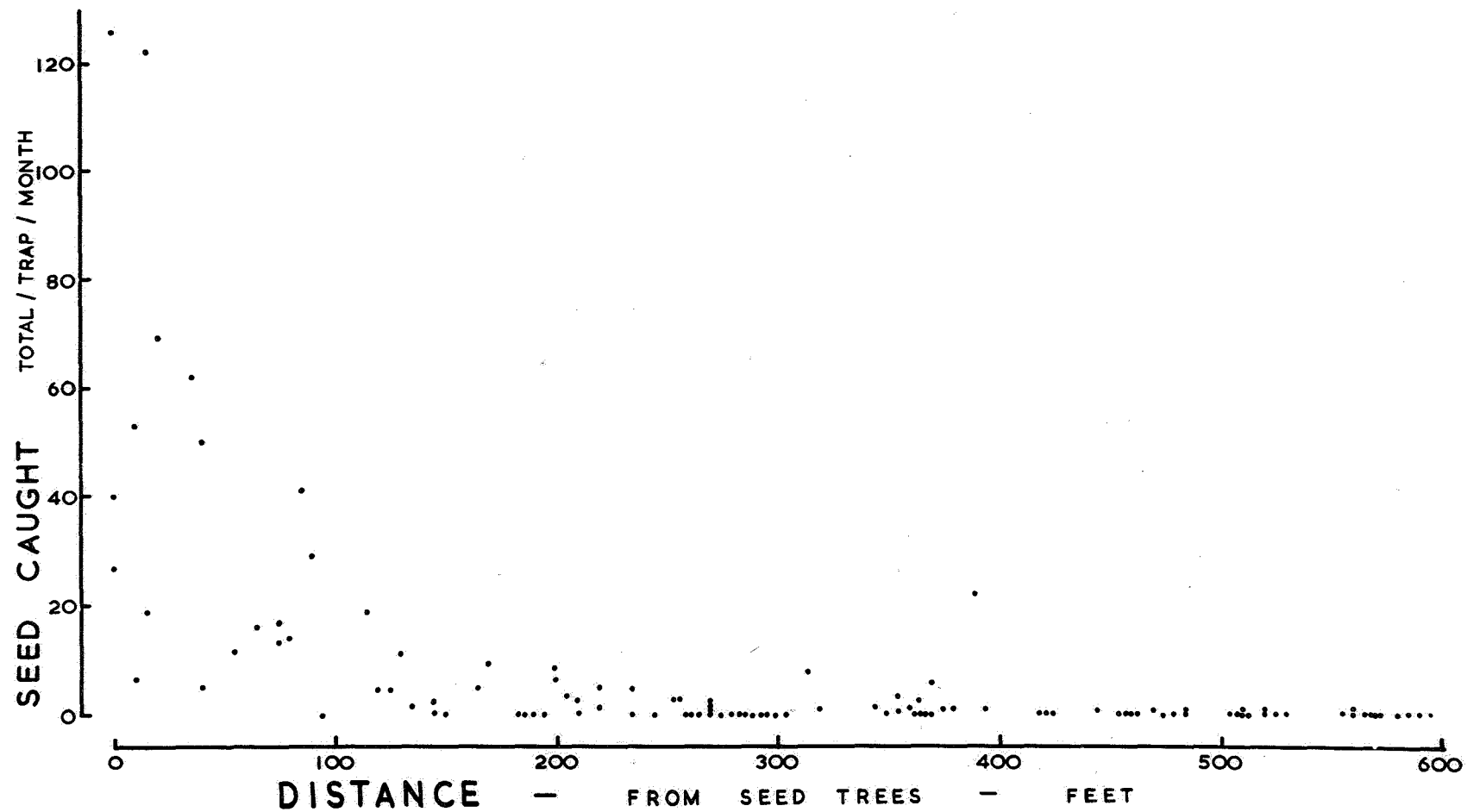


Fig. 29. DISPERSAL OF SEED. The number of seed (sound plus chaff) of *Eucalyptus regnans* caught per month per trap at certain distances in the south east from an edge of seed trees at Road 11, Florentine Valley. Trap area 1/4400 acre. Catches adjusted by the ratios of mean/actual catches of fixed trap north.

The positions of comparatively very good and very poor catches were mapped but it was not apparent that over the plot as a whole there had been zones of very good or very poor catches.

The very high value at 390 ft. (Fig.2.9) was due to the catch of a capsule containing six seeds.

Sound Seed. The data are given in Table 2.9 and graphed in Fig. 2.10. It is to be seen that:-

(1) the rate of fall of sound seed decreases very rapidly for the first 50 ft. from the tree and then less rapidly out to 200 ft. The mean rate of fall into the fixed trap was 6.5 per month, at 50 ft. about 3.9, at 100 ft. 2.3 and at 200 ft. from the trees 0.57 seeds per trap per month.

(2) beyond 200 ft. from the trees, catches of sound seed were sporadic (only 5 out of 77 occasions between 200 ft. and 500 ft.)

The pattern of the spread of regnans seed is similar to that found by Bateman (1947) for the spread of pollen by wind or insects. His investigations into pollen contamination in seed crops showed that successive increases in isolation distance became less and less effective in improving the isolation from contaminating pollen.

Summation of the actual catches of the roving traps for each 50 ft. interval from the trees gave information on the change in the proportion of sound seed to total seed with increased distance from the trees. The values are shown in Table 2.10.

TABLE 2.10 The proportion of sound seed to total seed of *E. regnans* falling at various distances from an edge of trees. Road 11, Florentine Valley.

	DISTANCES (FT) FROM EDGE OF TREES									
	0-50	50-100	100-150	150-200	200-250	250-300	300-350	350-400	400-450	450-500
Total no. seed caught	1003	214	41	29	26	12	20	38	1	2
% sound	13.4	13.1	21.9	10.35	0	0	5	10.5	0	0

Sound seed made up 13.1% of the total catch of the fixed trap (north) and this rate appeared to be maintained for at least 100 ft. from the trees, if not for twice that distance. Theoretically these observations could be correct. Fig. 2.8, prepared from the data on terminal velocities, shows the distances to which sound seed and chaff will be blown from capsules at various heights. On the Road 11 area the crowns are 100 ft. deep (150-250 ft) and seed falling from 200 ft. will be considered. If there were an even distribution of wind speeds between 0 and say 5 m.p.h. then all the chaff which fell would be evenly spread for a distance of 160 ft. from the trees but the sound seed would be spread over a distance of only 130 ft. (Wind eddies are not considered but in any case they would increase the spread of chaff compared with sound seed). So the proportion of sound seed could be expected to be slightly greater over distances up to 130 ft. in the conditions being considered.

On the Road 11 area, only on rare occasions could it be expected that sound seed would be caught beyond 400 ft. from the trees and chaff not often beyond 550 ft. If each type of seed was assumed to be shed from 200 ft. above the ground it follows from the values of Table 2.7 that during its fall sound seed would rarely be subjected to mean wind-speeds of more than about 15.5 m.p.h. and chaff 17.1 m.p.h. These values are shown on Fig. 2.8 and it can be seen that they are not underestimates as the top half of the crowns (200-250 ft) have not been considered.

There is an apparent anomaly in that the proportion of sound seed was maintained for some distance out from the seed trees and at the same time there was a rapid decline, over the same distance, in the absolute amount of seed caught. This is probably due to the fact that the nearer a trap is to an edge of seed trees, the wider is the sector from which winds may blow and still bring seeds to the trap.

The general conclusion reached is that, at Road 11 with north-westerly winds, the fall of seed was sporadic and at a low rate at distances greater than tree-height (250'). It will be shown that even at distances less than the height of the trees, the rate of fall of seed on the trap area would probably be inadequate to provide satisfactory numbers of seedlings.

Capsules. During the period 3.2.56 - 20.3.57 fifty positions were sampled in each of the three sub-plots; the mean length of the period of catch being 3.2 weeks. The catches of capsules were:-

Sub-plot I. 0' - 250'

<u>Distance from trees:</u>	0'	0'	15'	20'	40'	85'
<u>No. of capsules:</u>	2	2	3	3	5	3

- Sub-plot II. 250' - 500'
One catch of 1 capsule at 390'.
- Sub-plot III. 500' - 750'
No catch.

Except for one catch of 2 capsules at zero feet, all capsules contained some seed but the only capsule to contain viable seed was one at zero feet.

(b) Lords Area, Florentine Valley.

The traps were removed from this area after 410 days (February '56 - March '57) during which time 96 positions were sampled. Seed was caught on 10 occasions only - a single piece of chaff on nine and a single sound seed on the other one. The trees were 250 ft. high and two traps were at a maximum distance of 100 ft. from the trees. Although the trees were relatively young (150 years) their crowns were generally poor, with much die-back.

The extreme paucity of the seed-crop was not suspected but an indication of this was obtained later by the catch of mature capsules in litter trays in a nearby uncut stand. Between October '56 and January '58 only 22 mature capsules were caught in three trays, each 4.4 sq.ft. in section. Catches of buds etc. indicated that there may be a light flowering in 1959 which could yield a little seed by the beginning of 1960.

(c) Coupe W.48, Florentine Valley.

At the time of writing the investigation on this area had not advanced far enough to yield results. The data are given in Table 2.11 and the only trends apparent, after

four periods, are that more seed fell into the traps nearer the trees, and that compared with the Road 11 area, there were fewer zero catches beyond 200 ft.

TABLE 2.11 Dissemination of seed of *E. regnans* Coupe W.48, Florentine Valley.

Traps first exposed 26.9.57.

DATE COLLECTED	SEED TYPE	Distance (ft) from edge of seed trees and rate of fall - seeds/trap/month					
7.11.57		85	95	160	195	250	350
	Total	5.7	4.3	1.4	-	-	2.1
	Sound	1.4	1.4	-	-	-	-
16.12.57		10	15	175	215	355	360
	Total	3.8	16.2	0.8	-	-	0.8
	Sound	0.8	0.8	-	-	-	-
29. 1.58		110	115	165	195	275	315
	Total	4.8	2.0	1.4	1.4	1.4	0.7
	Sound	-	0.7	-	-	1.4	-
9. 3.58		105	110	175	195	290	340
	Total	3.8	6.1	-	-	0.8	1.5
	Sound	-	-	-	-	-	0.8

V. ASSESSMENT AND FORECAST OF CROPS OF SEED ON TREES OF EUCALYPTUS REGNANS.

1. Sampling by means of felled trees would be slow and costly because of the large size of the trees (several feet in diameter) and the relatively large number of sample trees required because of the great variation in the seed-crop from tree to tree.

The writer has found great difficulty in assessing, with the aid of field glasses, the relative numbers of buds and capsules carried on large, standing regnans. In addition inflorescence buds cannot be distinguished from leaf buds, and young flower buds are often hidden by leaves. It is impossible to decide the age of capsules.

However it was considered to be likely that during any period of time, greater numbers of buds and capsules would fall from trees carrying heavy crops than from trees carrying light crops, so that it would be possible that assessments of the numbers which fall could be used as the basis for the assessment of the number carried by the trees. Assessments and forecasts could be made valueless by losses caused by climatic conditions or animals but this problem would exist no matter what form of assessment were used.

These premises proved to be false but during the course of the investigations, information was obtained on the pattern and the rate of fall of buds and capsules. This information and a brief account of the investigations will be given.

If sample catches of dropped buds and capsules were to be used as the basis for the assessment and forecast of the seed crop, it was necessary to have some knowledge of the seasonal pattern of their fall. After a long search, four regnans trees were found on which inflorescences could be reached and counted at intervals. Of necessity they were young trees - two were 21 year-old saplings which were climbed to 40 and 50 feet and the others younger and within reach of the top of high stumps. Also three young obliqua on a poor site, were scored.

Seed traps and litter trays, in fixed positions, yielded information on the pattern of fall of parts of the inflorescence, without the numbers on the trees being known.

In anticipation that there was a seasonal pattern of fall and that it could be determined, pairs of trays were placed in coupes to be felled in the near future and left in position for 6-8 weeks. Catches of buds and capsules were then to be compared with the quantities on the heads of trees when they were felled.

2. LOSSES FROM THE TREE - E. REGNANS

Data from the periodic scoring of marked branchlets on the saplings of regnans and obliqua are shown in Table 2.12, in which is given the actual number of buds, capsules etc. present at each inspection. In June 1955, when the first counts were made, the 1957 flowers were present as inflorescence buds, the 1956 as buds, the 1955 as immature capsules and the 1954 flowers as mature capsules. Accordingly the starting point for the scoring of each flowering is shown (in Table 2.12) at the point each had reached, in

TABLE 2.12 Numbers of buds and capsules on marked twigs of *H. regnans* and *H. obliqua* (upper figure), and rates of loss - % per month since time of last inspection (lower figure). FIGS. 2.11 and 2.12

[illegible]

June '55, in the process of the development of the inflorescence. The data are depicted in this way in Figs. 2.11 and 2.12. To simplify this graph, the following data were not included:-

- (1) rates of loss based on less than 20 capsules
- (2) 1956 flowers on regnans No.8 after March '56, because counts of the capsules were not made during the period of heavy loss and so the pattern of loss could not be determined; and
- (3) regnans No.7, which died 2½ years after scoring commenced.

The general pattern of the loss of inflorescence parts was as follows:-

Inflorescence buds (Fig. 2.11). The up-and-down trends in scorings were due partly to the difficulty of distinguishing young inflorescence buds from leaf buds unless the buds are dissected. Inflorescence buds have been caught in traps in small numbers and generally their loss is not great. All the inflorescence buds, for 1957 flowers on regnans 7, were destroyed by beetles at the beginning of 1956.

Flower buds (Fig. 2.11). There was a heavy loss of flower buds at the time of their emergence from the inflorescence buds, but from June to December the rate of fall was low. The rate then began to increase immediately before flowering.

Capsules (Fig. 2.11). Potential capsules were lost in large numbers at the time of flowering and immediately afterwards. Failure of pollination or fertilization is thought to have been the main cause of loss. Persistent rain occurred while regnans 2 was flowering and the heavy losses between May and August were anticipated from the

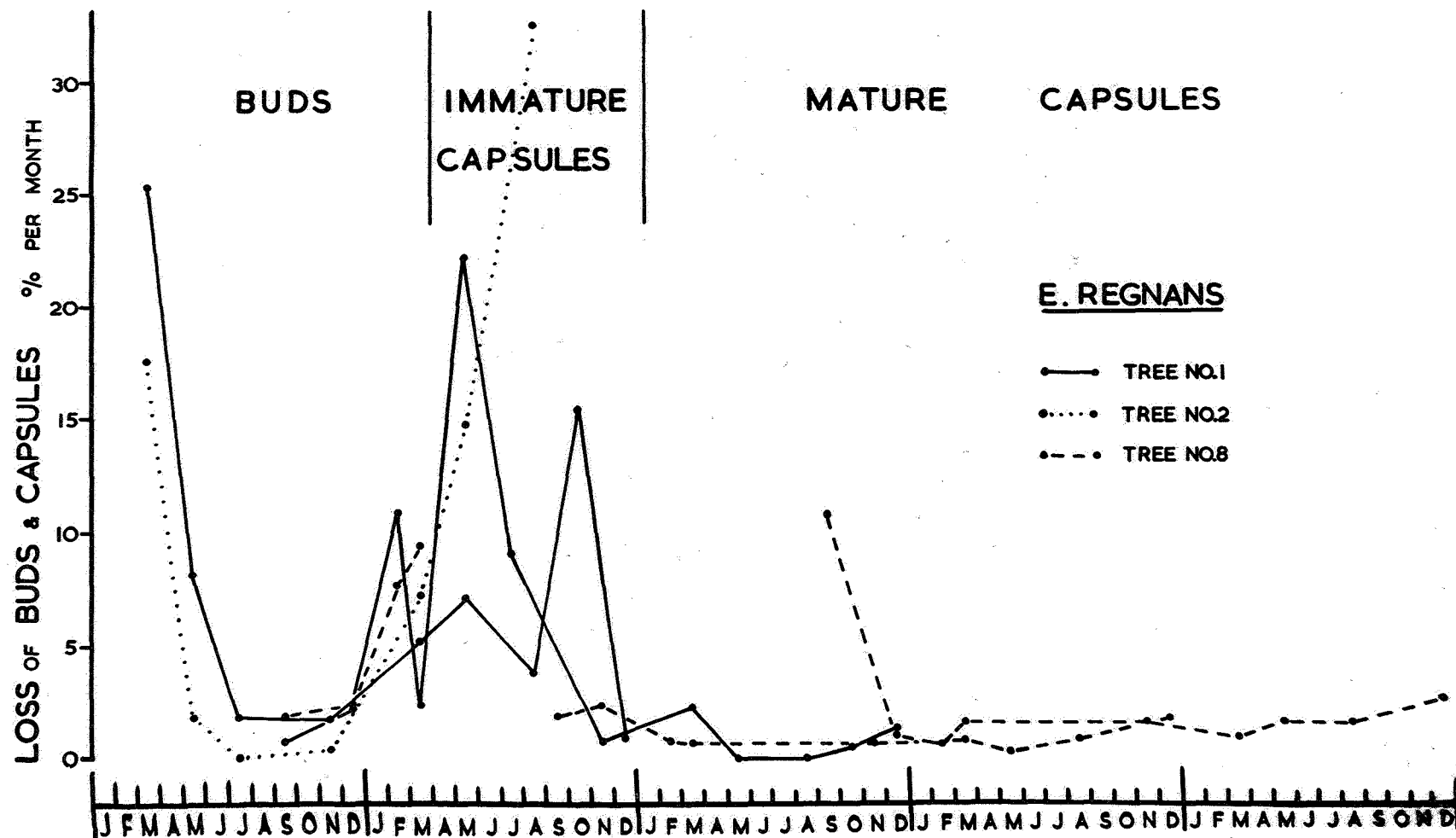


Fig. 2.11. THE RATE OF LOSS (% per month) OF BUDS AND CAPSULES from three trees of *Eucalyptus regnans* at Maydena. Data arranged according to stage of development of inflorescence.

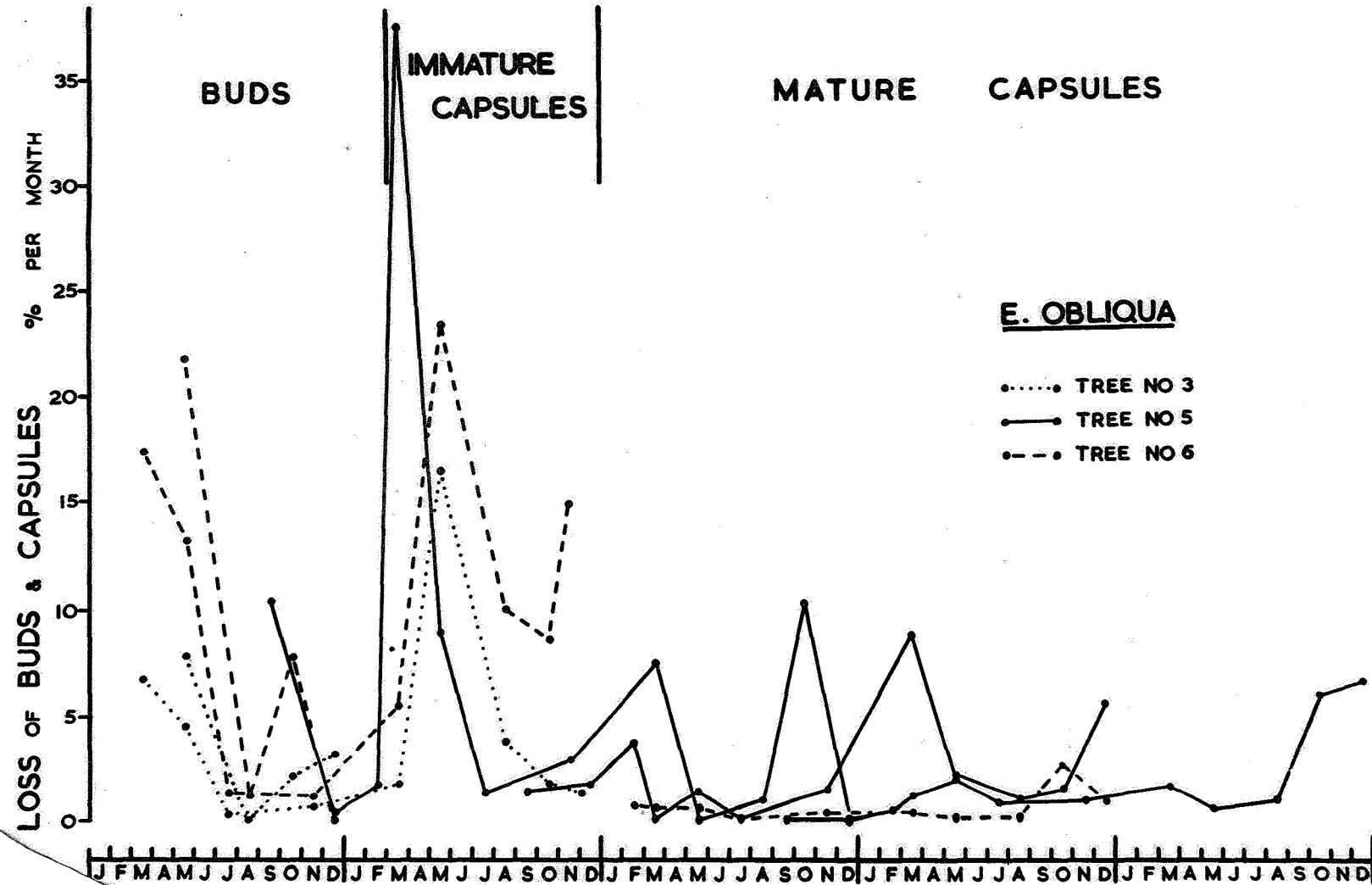


Fig. 2.12. THE RATE OF LOSS (%per month) OF BUDS AND CAPSULES from three trees of *Eucalyptus obliqua* at Maydena. Data arranged according to stage of development of inflorescence.

appearance of the flowers in May. For $1\frac{1}{2}$ years after flowering there was no clear pattern of the rate of loss. Two trees had low rates of loss after initial heavy losses but regnans 8 lost 10.8% of its '54 capsules in the period July-September of the year after flowering. Thereafter the rates of loss were low for all trees - generally less than 2% per month.

The data for obliqua (Table 2.12 and Fig. 2.12) show general trends similar to regnans except that after maturation of the capsules, losses were more sporadic and there was less uniformity between trees.

3. CATCHES IN FIXED TRAPS AND TRAYS - E. REGNANS

In Table 2.13 are shown periodic monthly rates of catch of buds and capsules in fixed seed-traps and litter trays at Road 11 during 1956 and 1957. The following comments are made:-

(a) Flower buds. Flowering in 1957 was poor and the indications in the Florentine generally were that 1958 would be poor also. Moderate catches of buds for the 1958 flowering were made in the seed-traps but otherwise catches were poor.

(b) "Capsules", immediately after flowering (1956,57)- Table 2.13. The 1956 flowering was heavy at Road 11 (fixed traps (T.F.) and litter trays (T.A.)) but poor at Lorde in the stand in which litter trays (T.B.) were exposed. The 1957 flowering was poor generally.

There were greater catches of "capsules" immediately after flowering than during later periods, with the catch ten times greater in the stands which flowered well.

(c) Mature capsules. Even in the stands which flowered well, few capsules were caught in the second year

TABLE 2.13

Mean monthly rates of catch of buds and capsules in fixed seed traps and litter trays. Florentine Valley.

Year & Mnth	YEAR OF FLOWERING											
	1954			1956			1957			1958		
	T.F	T.A	T.B	T.F	T.A	T.B	T.F	T.A	T.B	T.F	T.A	T.B
1956												
J.		4.6			21							
F.												
M.		4.8			91			4.6				
A.	0.8			246			6.3					
M.	2.9	12		95	181		4.4	2.4				
J.	1.6			32			3.3					
J.	-	9.5	-	3.5	34	-	-	0.6	1.1			
A.	1.3			11			0.9					
S.												
O.	0.7	12	-	12	33	0.4	1.3	4.9	0.6			
N.	-			10			3.2					
D.	-	13	-	5.5	36	0.5	1.0	0.2	0.6			
1957												
J.	9.4			3.0			0.7					
F.	4.9	5.8	0.3	1.5	4.3	0.3	-	0.6	0.5			
M.	0.5			-			1.6					
A.	-	6.2	0.2	-	1.1	-	5.6	1.3	1.3		1.5	0.4
M.	1.0			-			19			1.1		
J.	4.1	12	0.5	0.5	-	-	-	1.1	8.9	12	3.3	-
J.												
A.	1.9	1.4	-	-	0.4	-	-	0.9	6.0	6.3	1.1	-
S.	0.9	23	0.4	-	-	-	0.4	0.2	4.4	5.2	0.4	-
O.												
N.	3.1	26	1.4	-	-	-	0.9	-	5.7	13	1.0	-
D.	3.5	27	1.5	1.6	-	-	0.5	-	0.3	16	-	-
1958												
J.	0.4	8.0	0.7	3.7	-	-	-	-	0.3	1.7	-	0.3

T.F - fixed seed traps Road 11

T.A - litter trays Road 11

T.B - litter trays Lords

Trap 1/4396 ac.

Tray 1/4000 ac.

after flowering (see 1956 flowers - Table 2.13). Data covering the third and fourth years after flowering is given by capsules coming from the 1954 flowering. The fixed traps (T.F) and litter trays (T.A) at Road 11, were in a stand which flowered well and the litter trays at Lords (T.B) in a stand which flowered poorly. The overall picture is of higher rates of catch in the stands which flowered well; and if sample catches were made over periods of 3-4 months, differences in catch of practical significance would probably be obtained in stands in which flowering intensities were markedly different.

4. APPLICATION OF RESULTS

A study of the data concerning the rate of loss of buds and capsules from trees and the rate of catch in traps and trays in other stands indicate that sample catches of buds and capsules would be of limited value in making estimates of present and future crops of seed. At certain stages in the development of the inflorescence - as the flower buds emerge from the inflorescence buds, at flowering and in the third and fourth years after flowering - large proportions of the buds or capsules fall from the tree and sample catches could be used to estimate the number of buds or capsules on the tree. But for fairly long periods and over a wide range of flowering intensity, the absolute numbers of buds or capsules which fall from the tree may be small. Such periods are from June to December in the year before flowering and in the second and third years after flowering.

Twenty-one sample catches were made in various stands and confirmed the finding that such catches were indicative of the number of buds and capsules on the tree, only during the peak periods of fall mentioned in the last paragraph.

Long term (3-6 months) catches in numerous trays might give better results but it is considered that an investigation into assessments based on inspections from the ground, perhaps by telescope, would have greater chances of success. The long periods during which few buds and capsules may fall, even from trees carrying large numbers of umbels, remains a problem with any method based on relative numbers caught in trays.

PART THREE

FIELD GERMINATION

AND

EARLY SURVIVAL

OF

EUCALYPTUS REGNANS

FIELD GERMINATION AND EARLY SURVIVAL OF EUCALYPTUS REGNANSI. INTRODUCTION

When several thousand acres of mixed forest are destroyed by fire, favourable conditions arise for the regeneration of Eucalyptus but these conditions cannot be reproduced in their entirety as routine forestry practice for re-stocking cut-over areas. Conditions on cut-over areas, and particularly if logging is dispersed, differ from those found when virgin forest is destroyed by wild fire in many important respects such as:-

1. In any one locality the area cut each year is small compared with the area covered by past wild fires; coupes in the Florentine being 15-40 acres in extent and often widely separated from the next.

2. Usually wild fires completely destroy eucalypt-temperate rain forest mixtures but logging causes only a partial disturbance.

3. Fires burning in logging slash are quite different in character to those which burn in virgin forest.

4. The position with regard to the source of seed is altered.

Such differences are so marked that experimental evidence is not required to indicate the need to investigate the factors affecting Eucalyptus regeneration on cut-over areas, no matter how successful is regeneration following wild fire or how well the reasons for

success are understood. The results of counts of eucalypt seedlings on 208 millacre quadrats on cut-over areas in the Florentine Valley are shown in Table 3.1 (half of the plots established by the Forestry Commission).

TABLE 3.1 Eucalypt seedlings on millacre quadrats on cut-over areas in the Florentine Valley.

No. of Seedlings per <u>Quadrat</u> :	0	1	2	3	4	5	6	7	8	9	10	11	12
<u>No. of Quadrats</u> :	175	17	7	3	-	-	1	1	2	-	-	-	3
mean = 0.50; variance = 3.19													

The quadrats covered a wide range of sites, seed availability and time since logging (1-5 years). The over-dispersion in the data suggests that a negative binomial distribution is involved, a distribution which is often found in data concerning such phenomena as infectious diseases. The establishment of seedlings may be prevented or restricted by adverse conditions of seed supply, seed-bed, seed-harvesting insects, light and so on, but when such factors are simultaneously advantageous, large numbers of seedlings can be expected. This would appear to be a reasonable explanation of the data in Table 3.1 and indicates the need to have some knowledge of the part played by the major factors affecting the establishment of eucalypt regeneration on cut-over areas.

II. INVESTIGATIONS

1. INTRODUCTION

Investigations were confined to Eucalyptus regnans in the Florentine Valley. The following is a summary of the experiments established.

Experiment 1. Lord's plots. Established to study the effect on the germination and development of regnans of the condition of the seed-bed, the amount of seed, the activity of seed-harvesting insects and browsing mammals, and the season of sowing. Eighty-one plots, 16 x 16 ft., were arranged in a complete factorial design.

Experiment 2. Broadcast and spot-sowing trials used to obtain information on germination and early development. The plots were arranged in replicated blocks.

Experiment 3. Gap experiment. This experiment aimed to get information on the effect of the size of gaps in the canopy of the understory on the development of eucalypt seedlings. There were four replicates of each of the four gap-sizes investigated.

Experiment 4. Seed treatments, having as their objective the reduction of the loss of seed to insects. The plots were in replicated blocks.

Experiment 5. Sowings made to study the effect of hot, dry weather on the survival of very young seedlings. Replications of millacre plots on each of three types of seed-bed.

For location see Fig. 1.3A.

The results are not considered experiment by experiment. The information from all experiments has been brought together and will be discussed under the following headings:- rates of germination, the effect of the condition of the seed-bed, the effect of seed-harvesting insects, the death-rate amongst very young seedlings, the growth of the seedling and the effects of browsing by mammals.

2. EXPERIMENTAL DETAIL

EXPERIMENT 1. (Lord's plots)

1. Purpose: to study the effect on the germination and establishment of regnans of:

- (a) the condition of the seed-bed
- (b) the rate of seeding
- (c) the activity of seed-harvesting insects
- (d) browsing animals and
- (e) the season of sowing.

2. Forest Type: The original forest consisted of a 150 year old stand of regnans with a fully developed understory of rainforest species. Part of the area was lightly burnt in 1934 and a few regnans were killed. In the burnt areas an understory of Pomaderris and Olearia had developed. The stand was logged by high-lead in the summer of 1953/4 and burnt in the spring of 1954. The understory and rejected trees of regnans were largely knocked down by the logging and in an attempt to get generally uniform conditions trees which would have shaded plots were cut down in the winter of 1955. The plots were established 18 months after logging and 12 months after burning.

FIG. 3.1

(a) PLOT ON MINERAL SOIL
at Lords. Photographed
on 19.10.55, the day it
was sown with E. regnans.
Logging, summer 1953/54.

(b) PLOT ON BURNED SLASH
at Lords. Photographed
on 19.10.55, the day it
was sown with E. regnans.
Dicksonia antarctica in
top R; Histiopteris
incisa on R. Logged
summer 1953/54, burnt
spring 1954.

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FIG. 3.2

(a) PLOT ON UNBURNT SLASH
at Lords. Photographed on
19.10.55, the day it was sown
with E.regnans. Ferns at
nearer pegs are Polystichum
proliferum. Logs of
E.regnans in foreground and
on right. Trunk between
pegs is Dicksonia antarctica.
Logged summer 1953/54.

(b) Part of the area on which
BROADCAST AND SPOT-SOWING TRIALS
were established at Road 7A,
Florentine Valley. Nothofagus
and Atherosperma logged 1954/55;
burnt March 1955; small trees
felled July 1955; photographed
January 1956. Large trunks in
foreground are Nothofagus; small
light-coloured ones are Atheros-
perma.



3. Treatments.

(a) Seed-bed condition

1. bare mineral soil - Fig. 3.1
2. burnt slash - Fig. 3.1
3. unburnt slash - Fig. 3.2 (a)

The different seed-beds resulted from logging and burning and were not "artificially" prepared for the purpose of the experiment except to a limited extent to get more uniformity between plots e.g. loose chips and bark were removed from plots on mineral soil and live Dicksonia were removed from all plots because many did not carry them and some had specimens with a frond span of 10-12 ft.

(b) Rate of seeding

1. 4 lbs. per acre - c. $6 \text{ to } 6.5 \times 10^5$ viable seed.
2. 2 lbs. per acre
3. nil

Sowing was extended over a 2' wide buffer. Plots not sown were to give measure of the number of seedlings arising from seed other than that sown.

(c) "Animal" treatments

1. fenced against browsing native mammals and sprayed to reduce seed-harvesting by insects.
2. sprayed only
3. untreated

Basically the fencing was designed to exclude large ground marsupials (principally the wallabies - Wallabia and Thylogale) and consisted of 3'6" wire netting of $1\frac{1}{2}$ " mesh with a barbed wire above it. Special care had to be taken where the fence was constructed along or over large logs (2' - 5' in diameter).

The spraying treatment consisted of the application of a 0.5% emulsion of dieldrin, at a rate of 100 gallons per acre, to the plot and a buffer 4' wide. The spray was applied two days before sowing.

(d) Season

1. Spring 1955 - 19.10.55
2. Autumn 1956 - 13. 4.56
3. Spring 1956 - 11.10.56

The general logging pattern in the Florentine is of small single coupes or groups of coupes separated by strips of uncut forest. In spreading the establishment of the investigation over three seasons, it was necessary to decide between putting each season's plots on a recently logged coupe and so probably at a considerable distance from one another or putting all the plots on one coupe, with the last sowings on land a year "older" (since logging) than that on which the first sowings were made. The latter course was adopted as it was uncertain whether comparable coupes would be available and whether suitable slash-burning could be achieved.

4. Plot size 16' x 16'

The seed-beds were extremely variable and if plots had been a few square feet in area, a large number of replications would have been needed e.g. on areas on which the slash had been burnt there was variation in the severity of the burn, in the amount of small trunk and limb-wood, in the presence and position of large logs and stumps, etc. The establishment of the very large number of plots required would have been quite impracticable under the existing field conditions. If large plots had been used, sampling would have been necessary and the problem of extreme variations between small plots would have been transferred to small samples i.e. very large numbers of samples would have been needed. It was decided to use the largest plot on which it was considered that 100% scoring could be handled and not to replicate the 3x3x3x3 treatments. Plot sites were selectively chosen, avoiding such things as water holes on areas of disturbed mineral soil and treatments then randomly assigned to plots. A full statistical analysis proved unnecessary since results were so striking.

5. Lay-out.

A factorial design with the plots on each type of seed-bed regarded as a duplicate, the 27 plots in each arranged in 3 blocks of 9 plots each.

EXPERIMENT 2. Spot & Broadcast Sowing Trials, Road 7A

1. Purpose: to obtain information on germination and early development of the seedling (regnans).

2. Forest Type.

The area (9.6 acs.) had carried temperate rain-forest in which was one decadent regnans as well as a few snags, rotten stumps and fallen logs - the remnants of regnans which had died of old age. Nothofagus and Atherosperma were logged in 1954/55 and part of the slash burnt in March 1955. In July 1955 most of the trees left standing after logging were felled by Australian Newsprint Mills to open up the site for the establishment of eucalypts - Fig. 3.2(b).

3. Treatments

(a) Sowings

1. Spot-sowing. A pinch of regnans seed (c.20 viable seed plus chaff) was sown on roughly cultivated spots (6" x 6") at 10' intervals but sowing was not attempted where logging slash made movement difficult.

2. Broadcast sowing. The seed was mixed with dry sawdust and broadcast by hand, but sections were not sown on which spot-sowing would not have been attempted (had the plots been spot-sown). The seeding rate was $1\frac{1}{2}$ lbs. per whole plot, but for the sown area it varied somewhat from plot to plot. Mapping of the sown area gave a reasonable measure of the area of each plot which was sown.

(b) Time of sowings.

1. November 1955
2. April 1956

4. Size of plot: 0.6 ares

5. Lay-out: 4 plots in each of 4 replicated blocks.

6. Seeding

(a) Spot sowing: 100% of spots

(b) Broadcast sowing: 100 randomly selected circular samples (5' diameter) on each plot but only those on the sown areas were inspected. Natural seeding could be ignored.

EXPERIMENT 3. Gap Experiment - Road 10 Fig. 3.3

1. Purpose: A rain-forest understory absolutely prevents the establishment of eucalypt regeneration and quite commonly much of the understory remains standing after felling and logging. The purpose of this experiment was to obtain information on the size of gap, in the canopy of the understory, which was needed to allow eucalypt regeneration to become established.

2. Forest Type

The area had carried old mixed forest from which the regnans had been logged. The experiment was located within a few chains of the area from which the profile shown in Fig. 1.9 was taken. The understory was c.100 ft. tall.

3. Treatment

Gaps were located which had (or could be enlarged to have) approximately $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$ or $\frac{1}{16}$ the light intensity of the open. Light values were assessed by photo-electric cell readings of the amount of light reflected from the ground, it having been found that very obvious differences in the character of the ground material were needed before errors of assessment of light values were likely to be outside the large differences between the gaps. The effective sizes of gaps could not be selected on physical criteria because absolute size, shape, orientation in relation to the meridian and the height and density of the surrounding trees from the ground upwards, would all have to be taken into account. However it is possible to estimate comparative light values, from gap to gap, by getting a general impression of the physical features



Fig. 3. 3. Gap experiment. Fenced sub-plots on southern side of large gap. Large seedlings of *E. regnans* in each sub-plot from tubed plants, planted Oct. '56. Photograph March '58. Netting 42 ins. high.

of the gaps. In broad terms, the very small gaps were about 1/10 ac., and had understory trees on 75% of their perimeter.

- (i) Gaps: 4 sizes
 - (ii) Seed-bed: Plots cultivated with a Canterbury hoe.
 - (iii) Seeding: regnans at a rate of 4 lbs. per acre sown on 11/10/56.
 - (iv) Spraying: Extended over a 3' buffer; a 0.5% emulsion of dieldrin, 4 weeks prior to sowing. Rate 100 gallons per acre. Plots were sprayed to remove possible differences between gaps in the populations of seed-harvesting insects.
 - (v) Fencing: 3'6" high circular wire netting fences around each plot to remove the effects of browsing by ground animals.
 - (vi) Watering: Half the plots in each gap to be watered to remove the effect of root-competition from trees around the gap. This treatment was not applied because the 1956/57 summer was wet.
4. Size of Plots: 2 x 2 ft.
5. Lay-out: 8 plots in each gap; 4 replications.
6. Subsidiary.
- (i) To get "advance" information 2 tubed plants of regnans were planted alongside each plot, i.e. 16 in each gap.
 - (ii) As an adjunct to the main experiment, eight 2' x 2' plots were sown on 19/10/56 beneath an undisturbed canopy or rain-forest species. The plots were 2' x 2', seeded at a rate of 4 lbs. per acre but not sprayed or fenced. In addition two groups, each 8 plants, were

planted in the same area and enclosed in circular wire netting fences.

EXPERIMENT 4. Seed Treatment Experiment - Boggy Creek.

1. **Purpose:** to test the effectiveness of certain seed treatments in reducing losses of seed of regnans to seed-harvesting insects.

2. **Forest Type.**

Regnans forest, with an understory of Acacia, Olearia and Pomaderris, with some patches of Pteridium. logged in Aug.-Oct. 1954. Over much of the coupe the mineral soil was exposed by a bulldozer in a special operation by Australian Newsprint Mills to assist in the artificial establishment of eucalypts. All the plots were on this exposed mineral soil.

3. **Treatments.**

- (i) seed mixed with an equal quantity, by weight, of 20% D.D.T. dust.
- (ii) seed momentarily steeped in a 0.5% emulsion of dieldrin.
- (iii) seed untreated.

Sowing was done on 19/9/56 at the rate of 2 lbs. per acre.

4. **Size of Plots:** millacre with 4' buffers.

5. **Lay-out:** 6 replicated blocks.

EXPERIMENT 5. Sowings at Road 11

1. **Purpose.** The two summers experienced since the sowings at Lord's and elsewhere were cool and wet and the

sowings at Road 11 were made in the chance that the summer of 1957/58 would be hot and dry and that information would then be obtained on the effect of hot, dry weather on the survival of very young seedlings of regnans.

2. Forest Type.

150 year-old stand of regnans with a developing understory of rain-forest species. The eucalypts and part of the understory were logged in 1956/57 and a very small amount of the logging slash burnt in September 1957.

3. Treatment.

Seed was dusted with 50% D.D.T. dust and sown on 20/11/57 at the following rates:-

(i)	<u>bare mineral soil</u>	2 lbs. per acre
(ii)	<u>burnt slash</u>	4 lbs. per acre
(iii)	<u>unburnt slash</u>	6 lbs. per acre

It was expected that these sowing rates would yield 25 seedlings per plot.

The plots were not fenced but so that they would not differ from the immediately surrounding country and so perhaps be especially attractive to animals, seed was sown in the general vicinity of the plots.

4. Size of Plot: millacre with a 3' buffer.

5. Lay-out: 10 replications on each type of seed-bed except on burnt slash where only 6 plots could be established.

III. GERMINATIONS IN THE FIELD

1. GENERAL RATE OF GERMINATION

Table 3.2 shows the rates of germination in the field, at intervals of 30 days (month), for the experimental sowings made in the Florentine Valley.

If subjected to high temperatures, some seed of regnans develops a dormancy which has to be broken by a period of low temperatures before the seeds will germinate. In the field, seed is more likely to have such dormancy induced if it is sown in the springtime (rather than the autumn) and if it is sown in a position where it is fully exposed. This question will be discussed more fully in the next sub-section (2. Seed dormancy) but is mentioned here to explain the separation in Table 3.2 of the sowings made in the springtime but in positions with a considerable difference in the amount of shading.

Of the final number of germinations the mean percentage which had occurred after 30 days was much the same with spring and autumn sowings but during the next 30 days germinations on autumn-sown plots jumped to 75% but reached only 58% on spring-sown plots. On all plots germinations proceeded slowly through the winter followed by a slight but certain "burst" in December (13-14 months after the sowing of the spring plots and 8 months after sowing the autumn plots). More details of this "burst" are given under the section dealing with seed dormancy.

TABLE 3.2 Progress of Germination of *E. regnans*, expressed as % of the total observed number of germinations. Florentine Valley.

PLOTS	SOWN	DAYS SINCE SOWING															
		30	60	90	120	150	180	210	240	270	300	360	420	480	540		
Lords	19.10.55	14	51	71	76	81	84	87	90	90	91	92	94	97.5	100		
	11.10.56	31	65	82	90	94	96	96.5	97	98	98	98.5	100				
Broadcast Road 7A	7.11.55	38	60	70	82	85.5	87	89	92	93	94	96	98	99.5	100		
	MEANS:	28	58	74	83	87	89	91	93	94	94	95	97	99	100		
Seed Treatment	19. 9.56	28	59	84	93	97	99	99	100	100	100	100	100	100	100	---	Not Scored---
Lords	13. 4.56	52	76.5	83	85	89	90	91	93.5	96	98	99.5	99.5	100			
	MEANS:	46	74	83	87	89	91	93	96	98	99	100	100	100			
Road 10 Gap Exper. Under Canopy	11.10.56	59	75	83	86	89	90.5	92	94.5	97	98.5	100	100	100			
	19.10.56	18	87	93	97.5	99	100										
		23	86	96.5	100												

In the case of sowings in the gaps, germination had virtually finished after 5 months and no germinations occurred on the plots under the undisturbed canopy after 4 months.

2. SEED DORMANCY

Grose (1957 a) found the dormancy of some seed of regnans to be of the type "evidenced by slow or delayed germination" and that stratification of partially dormant seed such as regnans increased the rate of germination but not the total number of germinations. Some partially dormant seed became fully dormant when subjected to moist storage at temperatures above 60°F and the effect was most marked at temperatures above 70°F. Tests made by Grose with seed of lindleyana (syn. andreaana), (its seed is similar to regnans with regard to dormancy), in which unstratified seed was germinated at various temperatures, had given the following result after a period of 500 hours:-

Temperature °F	55	60	70	75
% Germination	90	80	50	10

Jacobs (1955) reported that seed of mountain species of eucalypts which are shed in autumn may not germinate until late in the following spring and Pryor (1955) found that stratification increased the rate of germination of seed of gigantea (and others). Cunningham (1955-58) working with regnans found that "stratification for 24-34 days at 38-40°F increased the germinative energy and brought about increases in germination capacity varying from 3-45% for different seed lots."

TABLE 3.3

1. Rates of Germination (number per plot per month)
E. regens Lord's Plots. Plot 16x16 ft. FIG. 3.4

SOWING	END OF PERIOD - DAY & MONTH																	
	4/1	8/2	29/2	5/4	3/5	12/6	11/7	14/8	17/9	23/11	19/12	22/1	21/2	11/4	24/7	10/10	18/12	
12.10.52	61	14	11	9	7	6	2	1	2	1	5	4	1	1	1	1	1	
All Plots	111	31	25	19	12	11	2	2	4	3	12	10	3	3	3	3	3	
Min. Soil																		
13. 4.56					60	87	12	4	5	2	10	5	1	1	1	1	1	
All Plots					89	136	23	3	6	14	23	10	9	9	9	9	9	
Min. Soil																		
11.10.56										104	113	33	20	7	2	1	2	
All Plots										105	138	47	27	9	5	1	6	
Min. Soil																		

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2. Rates of Germination (total number per month on all samples)
 Broadcast Plots. Road 7A.
 Total area of samples - Nov.'55: 0.10 ac.
 Apr.'56: 0.11 ac.

SOWING	9/12	20/12	23/1	21/2	14/3	30/4	28/5	25/6	24/7	28/8	4/11	4/12	10/1	4/4
	551	532	99	221	89	29		28	30	16	9	15	14	9
7/8.11.55														
16. 4.56							473	161	59	29	29	33	27	6

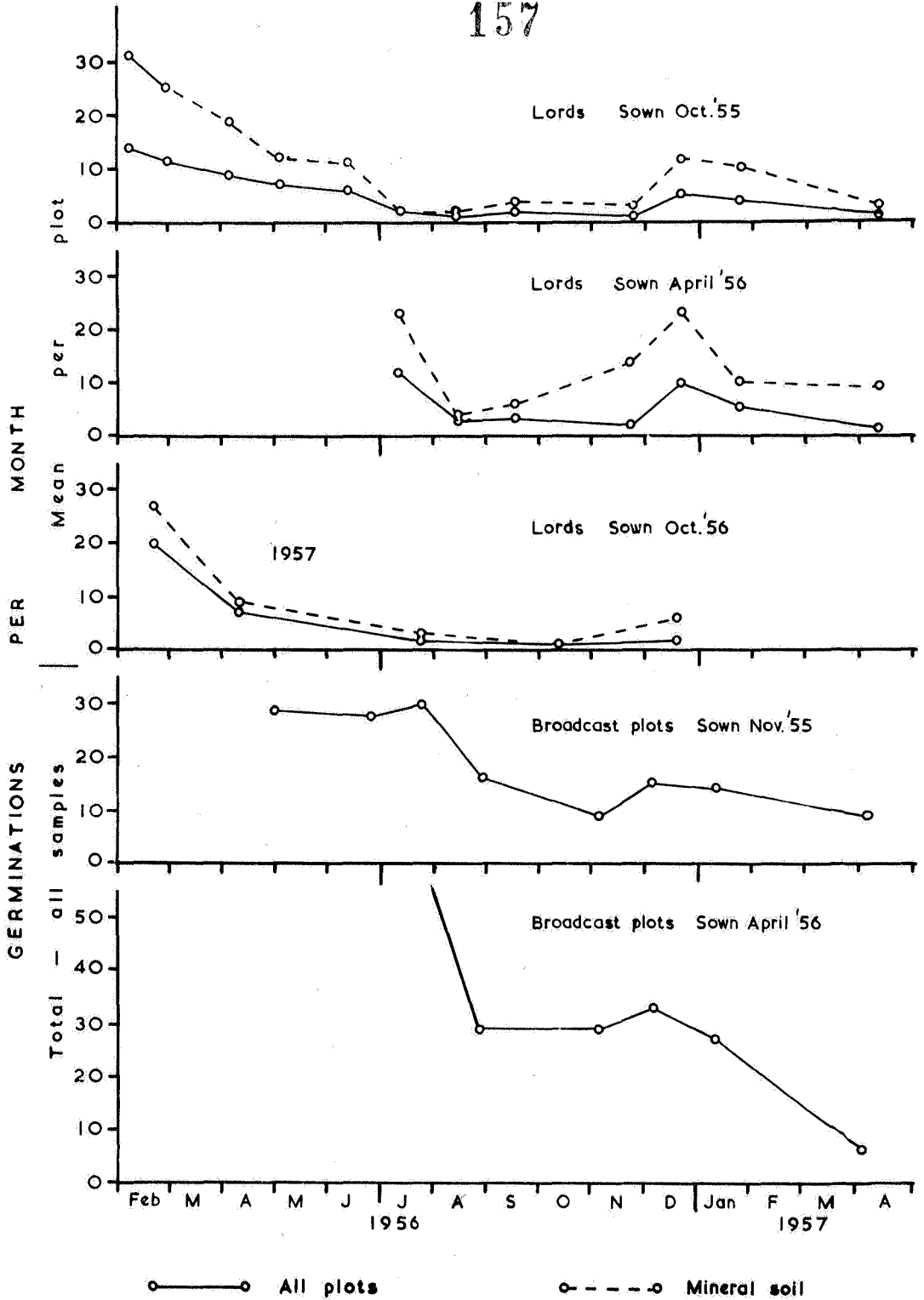


Fig. 3.4. DELAYED GERMINATIONS (No. per month) on plots at Lords, Florentine Valley, sown with *Eucalyptus regnans*, with increased rates of delayed germinations probably due to dormancy of seed induced in the field. Plots at Lords, 16x16ft. Total area of samples on broadcast plots was 0.091 acres for those sown November '55 and 0.114 acres for those sown April '56.

Grose with gigantea (syn. delegatensis) and Cunningham with regnans also found that secondary dormancy was induced in the field in the summertime. Cunningham found that 90°F for as short a period as 5 hours a day for 2 days caused moist regnans seed to become dormant and moist seed put in the field in bags made of black nylon-net developed dormancy in the same time and a period of low temperatures was required to break this induced dormancy.

In five of the eight sowings listed in Table 3.2 the effect of induced dormancy is evident - See Table 3.3 and Fig. 3.4. In two others - the gap experiment and the sowings under the full understory canopy - germinations ceased after 4-6 months and scoring of the seed-treatment experiment ceased before the delayed germination of dormant seed would have occurred.

For the plots at Lords, those on mineral soil remained barer than any others and the inducement of dormancy on the plots on mineral soil was stronger than the average for all plots.

It is probable that seed which does not germinate until a winter is past is of two main kinds:-

- (i) seed which is in a state of dormancy when sown and which requires a period of low temperatures to break the dormancy; and
- (ii) seed in which dormancy is induced by high temperatures in the field.

It is considered that over most of the year climatic conditions in areas such as the Florentine Valley would allow seeds to germinate quickly if they were in a germinable state. Prevention of germination by accident of position in, on or above the ground must

be rare indeed and if it occurs the position is likely to remain unchanged. Eucalypt seeds can germinate on sound logs and even while the seed is still in the capsule.

Except for short periods, the summers of 1955/56 and 1956/57 were good for the germination of seed. There is no doubt (from results) that conditions were very good during October-November and April-May. Yet many seeds remained dormant and did not germinate for more than 14 months after sowings in October.

3. EFFECT OF THE CONDITION OF THE SEED-BED ON GERMINATION.

In the case of Lord's plots (experiment 1), those on mineral soil were bare of logs and limbs, so that the actual area of seed-bed was not reduced by this material as was the case with the plots on areas of burnt or unburnt slash. So the plots on mineral soil were at an advantage, quite apart from any advantage inherent in bare, disturbed mineral-soil as a seed-bed.

The progressive pattern of germinations for each sowing in experiment 1, according to the condition of the seed-bed is shown in Fig. 3.5, in which each point represents the total number of germinations on 6 plots, each 16' x 16'. One thousand germinations is at a rate of 27,500 per acre.

For the sowings of October '55, plots on mineral soil showed an immediate and later increasing advantage over plots on slash - both burnt and unburnt. In terms of the total number of germinations per pound of seed

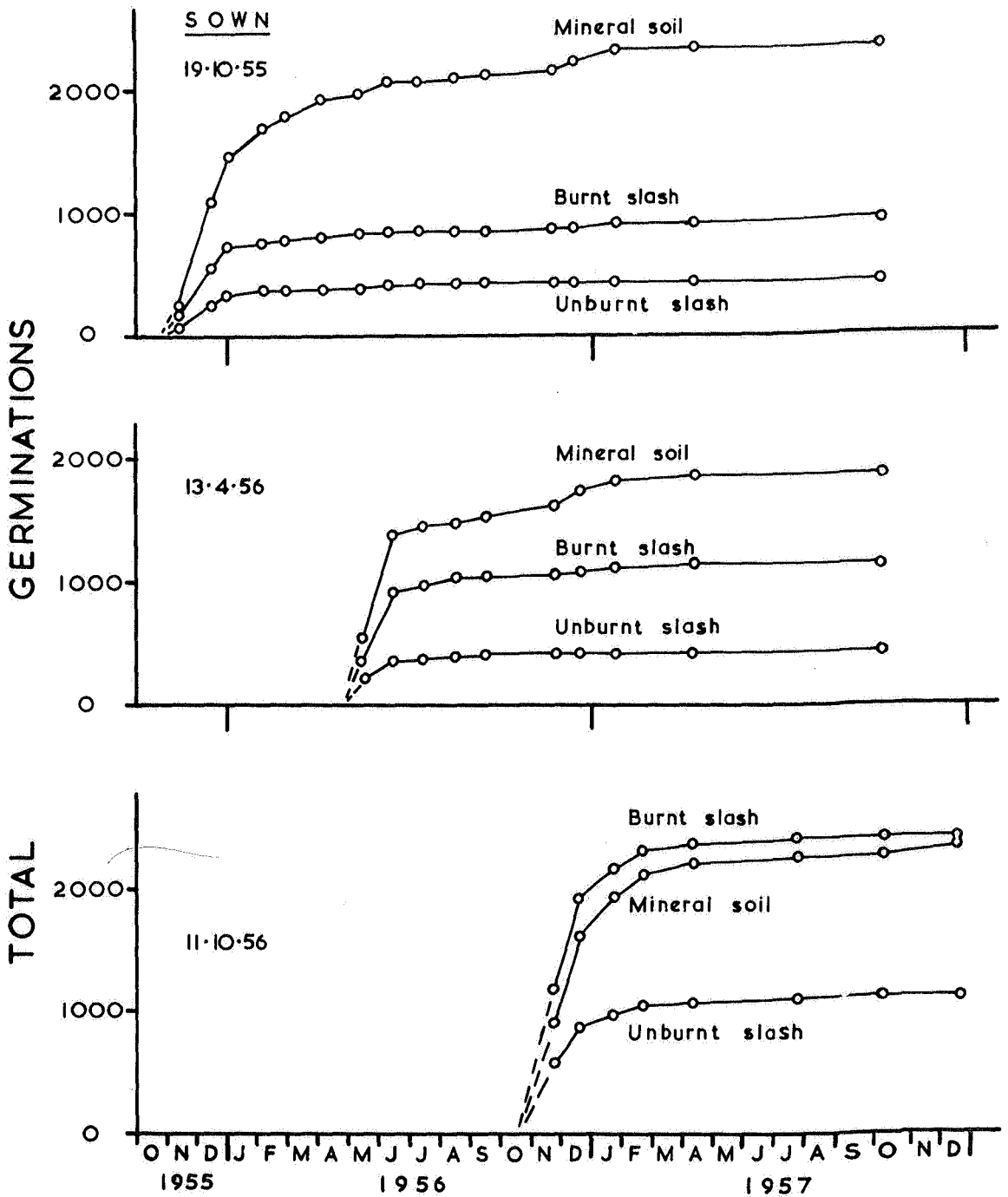


Fig. 3.5. EFFECTS OF CONDITION OF SEED-BED. Progressive numbers of germinations of *Eucalyptus regnans* on plots at Lords, Flor-entine Valley, according to time of sowing and conditions of seed-bed. Each point represents the total number of germinations on six plots, each 16 x 16 ft. Four of each 6 plots were sprayed to protect the seed from seed-robbing insects (1000 on graph = rate of 27,500 per acre).

sown, the results were:-

Mineral soil	22,300
Burnt slash	8,600
Unburnt slash	4,200

And for the later sowings:-

<u>April '56</u>	
Mineral soil	17,800
Burnt slash	10,800
Unburnt slash	4,000

<u>October '56</u>	
Mineral soil	22,350
Burnt slash	23,050
Unburnt slash	10,470

From the sowings of April '56, plots on mineral soil gave far more germinations than those on slash but the differences were less than in the previous sowing. This trend continued, with the sowings made in October '56, to the point where the plots on burnt slash had slightly more germinations than those on mineral soil. While the number of germinations on mineral-soil remained much the same for all sowings there was a relative improvement on burnt slash and for the last sowing a marked increase also on unburnt slash.

The seed-source was the same for all sowings and laboratory tests prior to sowings did not show an increase in the number of germinations per pound. In fact, in April '56 there were 157,000 germinations per pound and in October '56, 136,500.

The last sowings were on plots on which post-

logging changes were several months more advanced and soil conditions could be modified in this time by longer exposure to sun, wind and rain and by the growth of weed species. In Table 3.4 is shown the mean percentage (by ocular estimates) of the plots covered by fireweed (Erechtithites prenanthoides), ferns (principally Histiop-teris and Polystichum but not Dicksonia) and a ground mat of plants such as Oxalis, Haloragis and Bryophytes.

TABLE 3.4 Percentage of plot areas covered by fireweed etc. at the time of sowing - Experiment 1, Lords.

SEED-BED	TIME OF SOWING								
	Oct. 1955			April 1956			Oct. 1956		
	Fire-weed	Ferns	Ground Mat	Fire-weed	Ferns	Ground Mat	Fire-weed	Ferns	Ground Mat
Min. soil	1	-	6	7.5	0.5	19	11	1	40
Brnt. slash	1.5	2	1	26	7	14	24	9	4
Unbrnt. slash	6	5	3	18	18	-	15	15	6

The increase in fireweed cover occurred very shortly after the first sowings were made in October '55. At this time fireweed was present as scattered very large plants growing for the second (and last) year and very numerous small seedlings which had arisen from seed shed late in the previous summer from the scattered originals. By the beginning of December '55 the second year plants were 2-3.5 ft. high and seedling fireweed were up to 1 ft. high, with very large numbers 6-9 ins. high.

Fireweed was at a low ebb in September '56 and although the percentage cover in the summer of 1956/57 was about the same as in 1955/56, the plants were less vigorous.

There was a rapid increase in the ground mat of plants on the plots on mineral soil. Under adverse conditions (principally low soil-moisture) such vegetation would reduce the number of germinations but such an effect was nullified by the wet conditions of the early summer of 1956/57. On the slash plots, the more open "stands" of fireweed coupled with an abundance of rainfall allowed a large increase in the number of germinations in the last sowing.

For all sowings the mean number of germinations, per pound of seed, were as follows:-

Mineral soil	20,800
Burnt slash	14,150
Unburnt slash	6,200

Before dealing with germinations on seed-beds in other trials, it should be pointed out that two-thirds of the Lord's plots were sprayed to reduce the populations of seed-robbing insects and that on the average this treatment increased the number of germinations threefold. (The question of losses of seed to insects will be dealt with in Section IV - Seed-harvesting insects)

Gap Experiment (Exper.3). All plots were sprayed and the seed sown on mineral soil which had been cultivated with a Canterbury hoe (hoe with tynes instead of a blade). The mean number of germinations per pound was 70,000 with a range of 54,000 in small gaps to 104,000

in the large gaps. Such results could not be expected with any large scale operation.

Sowing under complete understory of rain forest species. The plots were not sprayed and not cultivated. Fingers were used to scrape the fairly thin, loose layer of litter from half the number of plots and on these plots 51,000 germinations per pound were obtained. On unscraped plots the figure was 7,500. All "seedlings" on all plots were dead in less than 8 months after sowing. The seed-bed on the scraped plots consisted of well-rotted litter which was moist and open in structure (but not loose).

Broadcast and spot-sowing trials (Exper.2).

(a) Broadcast sowings. Figures given below are the total of the maxima for the number of seedlings alive at any time on each sample and are not total germinations. Each sowing covered 2.4 acres and was on a cut-over, partially-burnt area which was not given any seed-bed preparation and was not sprayed. Samples were located at random and included "impossible" seed-beds such as logs, stumps and water holes. The number of seedlings per pound of seed sown were:-

sowing of	7.11.55	2,540
	16. 4.56	2,125

Such figures are likely to be more in keeping with the results to be obtained on large scale sowings than those for sowings where the seed-bed was prepared and the area sprayed. However seed-treatment and some selection of the places where seed is sown would give an increase on 2,500 seedlings per pound of seed.

(b) Spot sowing. Cultivation on the spots consisted of a light hoeing to a depth of 2-3 ins. over an area of about 6 ins. square. For the spot sowings made in November 1955 (2.4 acres) notes were made of the type of seed-bed on which each spot was located and a spot was considered to be successful if any germinations had occurred on it i.e. at this stage the seed-bed is not being considered in terms of its effect on survival of the young seedling. The result of the survey was:-

<u>SEED-BED</u>	<u>SUCCESSFUL SPOTS</u>
Ao layer - burnt - usually surface layers only	51
- unburnt	64
- all spots	59
Ao layer, somewhat disturbed, some mineral soil	79
Mineral soil, some organic matter	83
Mineral soil	84

Some mechanical disturbance of the Ao layer would appear to be needed to provide a reasonable seed-bed for Eucalyptus - it is in fact desirable for all the tree species observed - including those of the rain-forest. The slash fire did not often burn the Ao horizon completely, only the surface layers usually being affected and the result was a dry, powdery seed-bed. Moist organic material provides a good seed-bed but young eucalypt seedlings may not survive if their roots have to penetrate a long way to mineral soil. The fate of the seed which does not germinate will be discussed at the end of the next section.

IV. SEED-HARVESTING INSECTS

Investigations have been made by Ashton (1955), Cunningham (1955-58), Grose (1957 b) and Jacobs (1955) of the insects which harvest eucalypt seeds and the effects of their activities.

Ashton put out quantities of seed of regnans in the forest and found that in the summertime 90% of it was removed in two weeks. He dug over an area of 100 sq.feet in regnans forest at Wallaby Ck. (Victoria) and located 10 colonies of small black ants (Iridomyrmex). Such populations would mean that unless seed germinated fairly quickly it would have little chance to escape being harvested.

Using dieldrin sprays, Cunningham obtained an increased number of germinations in three trials with regnans. Details are given in Table 3.5

TABLE 3.5 Effects of spraying with dieldrin to reduce loss of seed of E.regnans to insects
(Cunningham)

SPRAYING TREATMENT		RATIO OF GERMINATIONS sprayed to unsprayed
Concentration	Rate:Galls/acre	
0.25%	80	3
0.07%	60	1.25
0.25%	60	3

Grose, working with gigantea (syn. delegatensis) found that "In trials using small covered trays, insects selected the whole loading, of approximately 400 seeds per tray, from all trays in 4 days, leaving only sterile ovules and empty seed coats." In a later trial, ground spraying with a 0.75% emulsion of dieldrin, and dusting of seeds with D.D.T., each proved effective in preventing this removal, while trays on non-sprayed ground and carrying untreated seeds were robbed of all full seeds within 3 days.

Jacobs reports two trials in which vastly different weather conditions caused eucalypt seed on unsprayed plots to be exposed to seed robbing insects for a short period in one case and a very long period in the other. In the first case very favourable conditions caused immediate and equally good germination on all plots but in the second, conditions for germination were adverse for 2 years and then when germination occurred fair numbers of seedlings appeared on the sprayed plots, but absolutely none on the unsprayed plots.

Lord's Plots (Exper. 4)

The cumulative number of germinations occurring on sprayed and unsprayed plots, for each of the three sowings, are shown in Table 3.6 and these results are shown in graphical form in Fig. 3.6.

The effect of spraying on the number of germinations was immediate and continuing. In summarized form the data are shown in Table 3.7.

TABLE 3.6

Effect of spraying. Cumulative germinations
of E. regnans Lord's Plots.
Plot 16 x 16 ft.
Each figure is the total for a set of 6 plots.
FIGURE 3.6

DAY & MONTH.	SOWN 19.10.55			SOWN 13. 4.56			SOWN 11.10.56		
	F&S	S	U	F&S	S	U	F&S	S	U
16/11	194	142	91						
14/12	775	776	298						
3/1	1047	1030	439						
6/2	1165	1141	501						
29/2	1215	1195	531						
5/4	1278	1269	553						
13/5	1318	1319	577	681	359	87			
11/6	1383	1356	611	1321	1073	242			
10/7	1394	1372	613	1416	1170	265			
13/8	1408	1380	615	1463	1200	273			
17/9	1423	1402	618	1500	1223	279			
19/11	1434	1429	630	1548	1283	289	999	1374	299
17/12	1455	1456	655	1616	1338	315	1726	2141	553
21/1	1477	1491	678	1663	1371	328	1992	2445	656
21/2							2109	2620	743
10/4	1503	1518	686	1689	1401	329	2184	2727	769
24/7							2224	2772	781
9/10	1509	1521	686	1691	1407	329	2230	2785	784
18/12							2267	2831	801

F&S - Fenced & Sprayed
S - Sprayed
U - Untreated

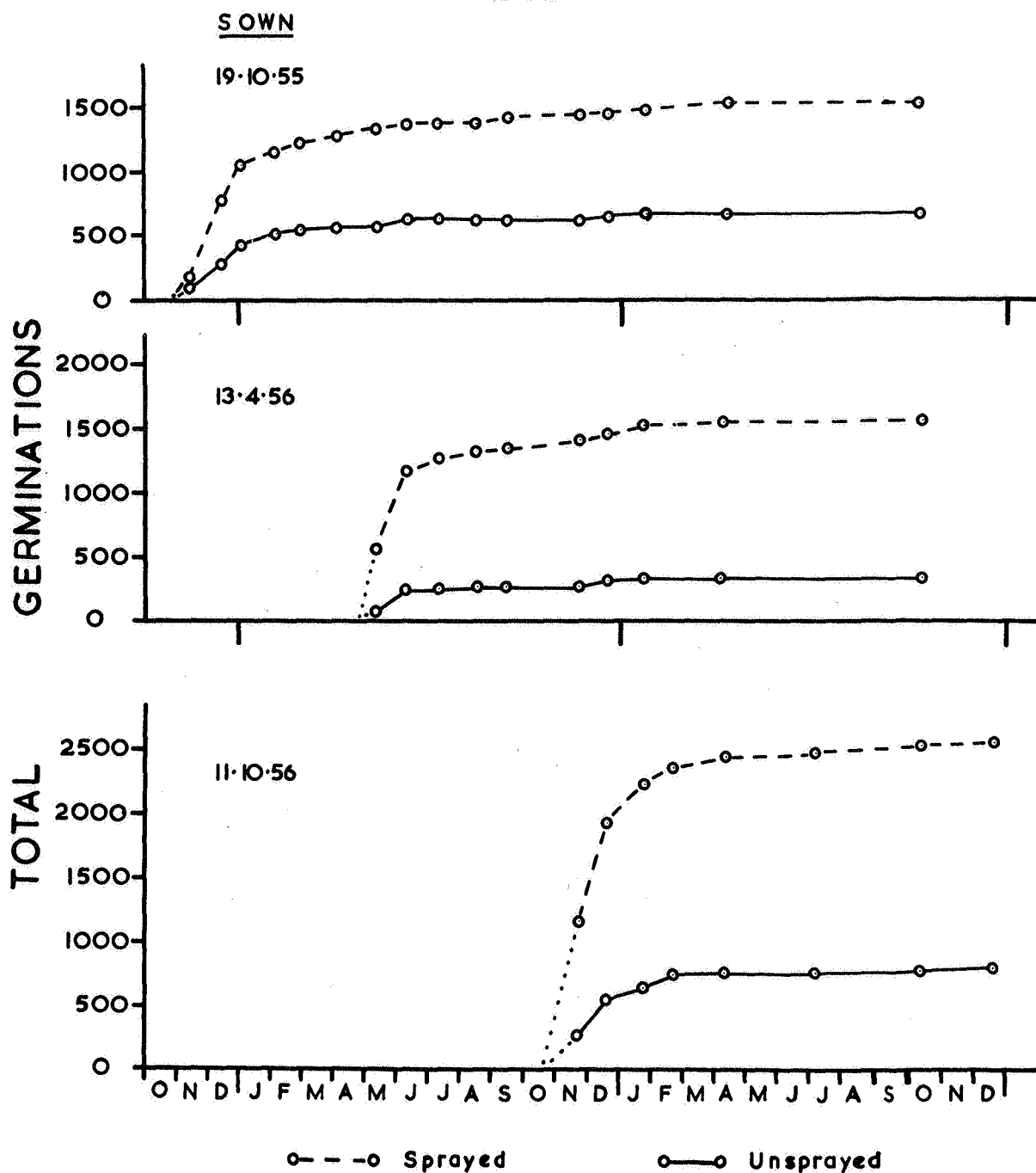


Fig. 3.6. EFFECT OF SPRAYING. (0.5% dieldrin, rate 100 galls/ac.) Progressive numbers of germinations of *Eucalyptus regnans* on sprayed and unsprayed plots at Lords, Florentine Valley. Each point represents the total number of germinations on a set of 6 unsprayed plots, or the mean of 2 sets of 6 sprayed plots (one set fenced). Plot size 16 x 16ft. (1000 on graph = rate of 27,500 per acre).

TABLE 3.7 Effect of Spraying. Total number of germinations to end of 1957.
E.regnans Lord's Plots (Exper.1)

SOWING	RATIO	
	SPRAYED	UNSPRAYED
Oct. '55	1515	686
Apr. '56	1549	329
Oct. '56	2549	801
TOTALS:	5613	1816

Sprayed: mean of totals for 2 sets,
each of 6 plots - one fenced.

Unsprayed: total for set of 6 plots.

In relation to the condition of the seed-bed, spraying was less effective on plots on mineral soil than on burnt or unburnt slash - Table 3.8.

TABLE 3.8 The ratios of the total number of germinations on sprayed and unsprayed plots according to the condition of the seed-bed.
E.regnans. Lord's Plots (Exper.1)

SOWING	SEED-BED	RATIO	
		SPRAYED	UNSPRAYED
Oct. '55	Mineral soil	1.8	
	Burnt slash	6.2	
	Unburnt slash	1.8	
Apr. '56	Mineral soil	3.2	
	Burnt slash	7.9	
	Unburnt slash	10.0	
Oct. '56	Mineral soil	2.4	
	Burnt slash	3.4	
	Unburnt slash	6.5	
All	Mineral soil	2.3	
	Burnt slash	4.5	
	Unburnt slash	4.5	

The smaller effect of spraying on the plots on mineral-soil was almost certainly due to the fact that fewer ants were present than on plots on burnt or unburnt slash. On the areas on which the mineral-soil plots were situated insect nests would have been broken up by the movement of tractors and logs and on much of the area consolidation of the soil would have made the destruction of nests more complete and their re-establishment difficult. No certain discovery of a colony of ants was made on disturbed mineral soil, whereas diggings of a couple of square feet on slash areas (burnt or unburnt) found nests on an average of once in three attempts.

Grose (1957 b) reports the lygaeid bug Dieuches notatus Stal (as well as certain ants) to be most significant in causing losses of seed in gigantea (syn. delegatensis) forests in N.E. Victoria. Bugs of the same genus (and probably the same species) are present in very large numbers in the Florentine Valley and although they have not been observed to harvest seed it is highly probable, from the pattern of their behaviour, that they do so. They move around on logs and on the ground as if foraging and are infrequently found on plants.

The question of seed whose germination is delayed, because of induced dormancy, has been dealt with, the pattern and rate of germination of such seed being given in Table 3.3 and Figure 3.4. It was pointed out that the inducing of dormancy was strongest on the plots of mineral soil.

The rate and pattern of germinations, on the basis of the number of germinations per month, are shown, by spraying treatment, in Table 3.9 and Fig. 3.7. Table 3.9

TABLE 3.9

Number of germinations per month on sprayed and unsprayed plots. E. regnans Lord's Plots. Plot 16 x 16 ft. Totals for units of 6 plots. Dates midway between scorings. FIGURE 3.7

DAY & MONTH.	SOWN 19.10.55			SOWN 13. 4.56			SOWN 11.10.56		
	F&S	S	U	F&S	S	U	F&S	S	U
25/12	408	436	211						
21/1	101	93	53						
18/2	71	77	40						
18/3	52	62	20						
19/4	43	54	24	658	347	84			
23/5	49	28	25	662	739	160			
27/6	11	17	2	98	90	24			
28/7	12	7	2	41	26	7			
31/8	13	19	3	33	25	5			
20/10	5	5	5	21	18	4	697	939	208
6/12	24	31	29	78	77	30	839	885	293
5/1	19	31	20	41	32	11	235	277	91
6/2							117	165	87
3/3	10	10	3	10	11	4			
18/3							46	65	16
2/6							11.5	13	3.5
11/7	0.9	0.4	-	0.3	1.0	-			
1/9							2	5	1.5
13/11							16	20	7.5

F&S - Fenced & Sprayed
S - Sprayed
U - Untreated

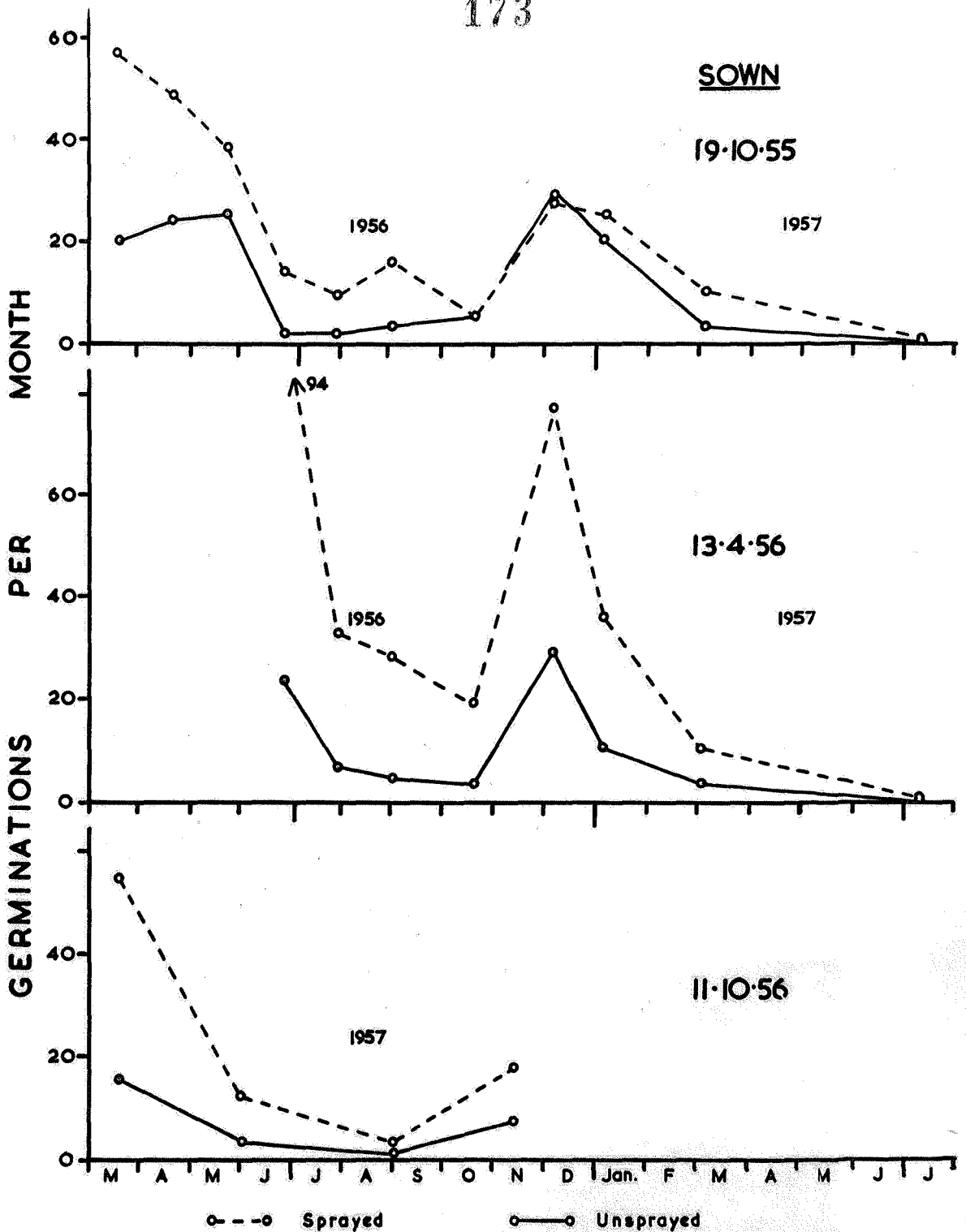


Fig. 3.7. EFFECT OF SPRAYING (0.5% dieldrin, rate 100 galls/ac). The number of germinations per month of *Eucalyptus regnans* on sprayed and unsprayed plots at Lords, Florentine Valley. Each point represents the total number of germinations per month on a set of 6 unsprayed plots or the mean of 2 sets of 6 sprayed plots (one set fenced). Plot size 16 x 16ft.

shows the data from the time of first scoring, but Fig. 3.7 only covers the period of delayed germinations.

The effect of spraying was evident for about 12 months. This is true for the spraying done in October '55 and April '56 and probably so in the case of the spraying done in October '56. So for the sowings made in October '55, the germination of dormant seeds in December '56 came after spraying was no longer effective and as many delayed germinations occurred on non-sprayed as on sprayed plots. However spraying was still effective on the plots sown in April '56, 2.6 times as many delayed germinations occurring on sprayed as on unsprayed plots. The position with regard to the plots sown in October '56 is uncertain.

It is to be noted that one-third of the plots at Lord's (Exper.1) were left unsown so that a measure of natural regeneration could be obtained. The number of seedlings appearing on these plots were so few that no allowance for them need be made in the scorings of sown-plots and they in no way effect the position regarding delayed germinations.

The rate and pattern of delayed germinations, according to the condition of the seed-bed and spraying treatment, are shown in Table 3.10.

TABLE 3.10

Number of germinations per month
on sprayed and unsprayed plots on
various seed-beds. E. regnans
Lord's Plots. Plot 16 x 16 ft.

Totals for units of 2 plots.
Dates midway between scorings.

SOW- ING	DATE Day & Month	MINERAL SOIL		BURNT SLASH		UNBURNT SLASH	
		Sprayed	Not Sprayed	Sprayed	Not Sprayed	Sprayed	Not Sprayed
<u>19</u> <u>10</u> '55	28/7	6.2	1.8	0.9	-	2.2	-
	31/8	11	4.4	4.4	-	1.3	-
	20/10	7	5.4	0.9	0.4	0.4	-
	6/12	22.5	23	5.2	1.2	1.2	-
	5/1	19	20	4	-	1.8	-
	3/3	7	2.7	2.5	-	0.4	0.4
	11/7	0.4	-	0.4	-	-	-
<u>13</u> <u>4</u> '56	28/7	7.1	4.4	23	2.6	4	-
	31/8	15.5	2.6	7.5	2.6	5.3	-
	20/11	17.0	4	1.8	0.9	0.9	-
	6/12	66	27	12	3.5	-	-
	5/1	21	11	15	-	0.9	-
	3/3	8.5	4.2	1.3	-	0.6	-
	11/7	0.3	-	0.2	-	0.1	-
<u>11</u> <u>10</u> '57	18/3	22	11	24	3.1	9.2	1.8
	2/6	6.8	3.5	3.8	-	1.7	-
	1/9	2.5	1.2	0.6	-	0.6	-
	13/11	15	7.4	2.2	-	0.4	-

The following points emerge from Table 3.10:-

(1) By far the greatest number of delayed germinations occurred on mineral soil, the relative numbers per month for the three sowings being 166 on mineral soil, 24 on burnt slash and less than 2 on unburnt slash. This is to be expected if the delayed germinations largely stem from seed in which dormancy has been induced by high temperatures.

(2) By the time the flush of delayed germinations occurred on the plots sown in October '55 the effect of spraying had disappeared and there were as many germinations on unsprayed as sprayed plots. This might be explained by suggesting that insects quickly harvest most of the seed on unsprayed plots but that a certain minimum escape them. However on unsprayed plots, the number of germinations does not fall to almost zero within a few months of sowing. So it is unlikely that the supply of seed, remaining on sprayed plots when the effect of spraying ceased would, in two months, be reduced by insects to the level on unsprayed plots, where foraging for seed had been going on for 12 months. It is possible that seed in which dormancy has been induced is not attractive to the insects e.g. the bug Diuchesa, being a sucking insect may not collect seed unless it is about to germinate or even may be able to discard seed which would not germinate in the galleries to which it takes it (the temperature may not be low enough in the galleries to break dormancy).

A relatively high rate of delayed germination could be expected on the sprayed plots on mineral soil because the effect of spraying had not long ceased and insect populations were probably low. But loss of seed to insects had occurred with all sowings on the unsprayed

plots on mineral soil (spraying increased germinations 1.8, 3.2 and 2.4 times) so that in spite of insect activity - albeit at a lower intensity than on slash plots - an appreciable amount of viable seed remained on or in the seed-bed on the unsprayed plots for periods of up to 15 months before it germinated. The numbers of delayed germinations on unsprayed plots on mineral soils and their relation to total germinations is shown in Table 3.11.

(3) Seed-harvesting on the unsprayed plots on burnt and unburnt slash was very thorough - see Table 3.12.

TABLE 3.11 Number of delayed germinations on unsprayed plots on mineral soil. E.regnans. Lord's Plot (Exper.1).
Total for 2 plots for each sowing.

SOWING	TOTAL GERMINATIONS	DELAYED GERMINATIONS		
		Period	Number	% of Total
19.10.55	235	19.11.56-21.1.57	47	20
13. 4.56	255	" "	36	14
11.10.56	419	10.10.57-30.1.58	30	7

TABLE 3.12 Number of delayed germinations on unsprayed plots on burnt and unburnt slash. E.regnans Lord's Plots (Exper.1).
Total for units of 2 plots.

SOWINGS	NUMBER OF GERMINATIONS		
	Period	Burnt Slash	Unburnt Slash
19.10.55	11.6.56 - 9.10.57	2	2
13. 4.56	14.8.56 - 9.10.57	5	
"	11.7.56 - 9.10.57		N11
11.10.56	11.4.57 - 18.12.57	N11	N11

Seed Treatment Plots (Exper. 4)

In cases of doubtfully adequate seed-supply, control of seed-harvesting insects would be of great benefit but as a large scale operation in heavy-forest country the application of 75-100 gallons of spray material per acre would be more costly than collecting and sowing additional seed.

Grose (1957 b) obtained protection for gigantea (syn. delagetensis) seed by dusting the seed with D.D.T. He also steeped seed momentarily in a dieldrin emulsion but found that although germination was not affected, elongation of the radicle and the development of root hairs were inhibited. This was not observed by me in laboratory trials and in the field the number and rate of germination of seed so treated was not different from untreated seed nor was early survival affected - Fig.3.8.

The protection given by dusting with D.T.T. was immediate and marked (Fig. 3.8) despite good conditions for germination which meant that the unprotected seed would have been exposed to insect attack for only a short period.

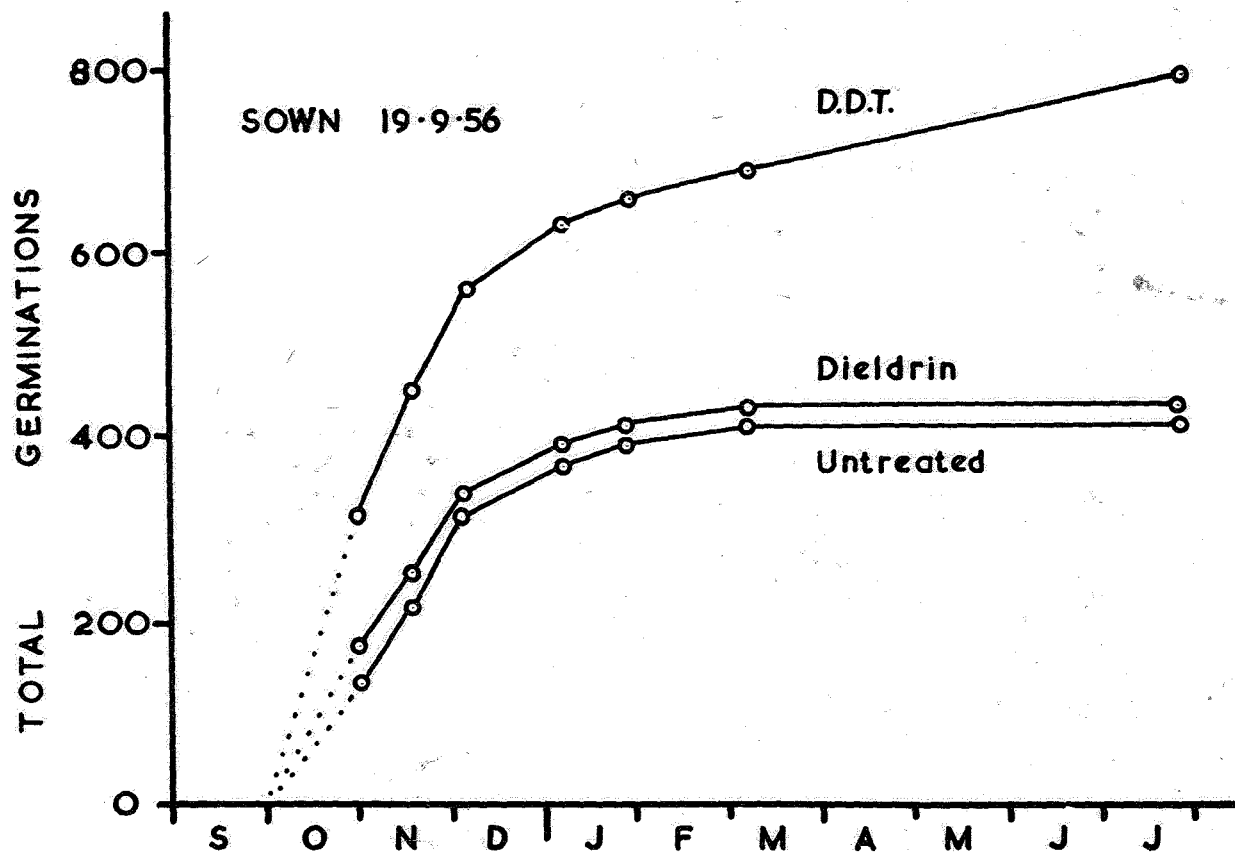


Fig. 3.8. EFFECT OF TREATMENT OF SEED on the total number of germinations of Eucalyptus regnans Treatments - (1) Seed mixed with an equal quantity (weight) of 20% D. D. T. dust. (2) seed steeped for a few seconds in a 0.5% emulsion of dieldrin. (3) untreated. Each point represents total of 6 millacre plots. Boggy Creek. Florentine Valley.

V. SURVIVAL OF VERY YOUNG SEEDLINGS

1. GENERAL

The survival of young seedlings was influenced to a very large extent by the wet summers of 1955/56 and 56/57. Monthly rainfall figures for the Florentine Valley were:-

Mnth.	<u>LORDS</u>			<u>TIM SHBA</u>		
	1955	1956	1957	1955	1956	1957
Jan.		430	281	393	402	442
Feb.		192	137	166	117	173
Mar.		142	253	245	214	353
Apr.		562	553	424	665	641
May		237	505	604	245	718
June		623	269	345	706	443
July		533	101	770	638	86
Aug.		643	136	711	775	261
Sept.		217	548	333	318	604
Oct.	588	490	493	570	634	659
Nov.	744	696	435	937	868	544
Dec.	346	391	587	457	782	748

Conditions were good for the development of fungi and this was particularly the case near ground-level among patches of ferns or fireweeds or amongst logging slash. Heavy losses of seedlings through attacks by damping-off fungi were to be expected. Moisture contents of surface soils from the plots of the gap exper-

iment at Road 10 (Exper. 3) were determined early in March 1957 and the means for all gaps (16) were between 30-40%. The lowest values were 16 and 19% (these were not from the same gap) and it is doubtful whether the soil was drier at any other time during the 1956/57 summer. The 1955/56 summer was wet and at Lords more rain fell during January and February in 1956 than in 1957. Very heavy rains fell in eastern Tasmania during January and February 1956 and the influence of the E.-S.E. rain-bearing winds was more strongly felt at Lords than on Tim Shea. The gauges were about 9 miles apart and the Road 10 plots were half-way in between.

2. LORD'S PLOTS (Exper. 1)

The rates of death of the "seedlings" of regnans from time of first scorings are shown in Table 3.13 and in fig. 3.9. All plots were included in the data until such time as the effects of browsing became evident and from then only fenced plots were considered.

Generally the death rate was much lower on mineral soil than on burnt or unburnt slash. The plots on mineral soil were on areas on which the mineral soil had been churned up by tractors and snigged logs. There was a great deal of consolidation and Erechthites was far less successful on such a seed-bed than on burnt or unburnt slash. So the young eucalypt seedlings on the slash plots had grown for most of the time under conditions of higher atmospheric humidity and poorer air circulation than on mineral soil. For long periods seedlings sheltered by slash, fireweed or ferns were permanently wet and the summers of 1955/56 and 56/57 were so wet that soil-moisture was almost certainly adequate except perhaps

TABLE 3.13

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DEATHS - % per month (% of seedlings alive
at previous scoring)
E. regnans Lord's Plots FIG.3.9

DAY & Mnth.	SOWN 19.10.55			SOWN 13. 4.56			SOWN 11.10.56		
	M.S.	B.S.	U.S.	M.S.	B.S.	U.S.	M.S.	B.S.	U.S.
25/12	12.5	21.6	16.0						
21/1	7.2	19.7	15.8						
18/2	10.1	26.6	21.0						
18/3	5.1	12.9	16.2						
19/4	3.5	12.7	16.0						
23/5	4.2	11.3	13.5	9.6	18.0	37.4			
27/6	6.1	6.0	13.6	23.2	27.6	40.0			
28/7	6.9	11.7	13.8	18.5	15.8	18.3			
31/8	4.7	7.1	10.3	7.6	9.4	10.7			
20/10	1.8	9.5	9.1	4.8	11.4	15.3			
6/12	1.3	4.4	14.8	2.0	17.6	4.4	13.4	12.1	14.5
5/1	1.2	4.5	10.4	2.5	11.0	4.7	5.9	12.1	12.1
6/2							6.9	11.4	9.6
3/3	0.6	5.9	8.0	1.5	10.8	10.4			
17/3							6.5	13.5	14.2
2/6							6.3	6.8	7.6
11/7	0.7	1.4	5.9	2.2	7.0	7.5			
1/9							5.2	11.1	10.7
13/11							3.3	15.3	7.5

No. of Plots: 19.10.55 6 on each seed-bed to 18.2.56
2 " " " after "

Plot 16x16 ft. 13. 4.56 6 " " " to 31.8.56
2 " " " after "

11.10.56 6 " " " to 17.3.57
2 " " " after "

M.S. + Mineral Soil
B.S. - Burnt Slash
U.S. - Unburnt Slash

for very short periods.

The positions of seedlings were marked from the time of first scoring - usually at the cotyledon stage - and although many small seedlings disappeared between inspections, most seedlings which had died could be found and a cause often ascribed to their death.

Only to a very limited degree was frost apparently the cause of the death of young seedlings and in any case the much better development of ferns and fireweeds on slash plots would afford protection from frost. Insect attack was easily recognized, but rarely caused deaths. A large proportion of the dead seedlings (at the cotyledon and first-leaf stage) were flaccid. Usually the plants had not fallen over in the way that is typical of attacks by damping-off fungi in the glasshouse and it was often difficult to decide whether a plant was alive or dead. Shrivelled leaves were not common and when they occurred it was usually fairly certain that the plant had died from lack of water. Such was the case with seedlings on pieces of rotten wood. No attempt has been made to identify the fungi concerned.

Fungi can be expected to drastically reduce the numbers of small seedlings in areas such as the Florentine, where several inches of rain may fall in any month and conditions of high humidity near ground-level would be the rule over most of the year, except on bare sites. Amongst dense fireweed, etiolated seedlings as tall as 6-9 ins. have been observed which were literally rotting away. This indicates the high death-rate to be expected at the cotyledon stage as for example in June 1956, when two months after sowing (Exper.1) plots on mineral soil, burnt slash and unburnt

slash had seedling death-rates of 23, 28 and 40% respectively (Table 3.13).

The data of Table 3.13 can be summarized as follows:-

Sowing in October '55. The death-rate on the plots on mineral soil was above 10% twice only and, except on one occasion (6.1% c.f. 6.0%), was less than that on slash plots from December '55 to December '57. For all plots the death-rate was highest for the first 4 months after sowing and then declined.

Sowing in April '56. The death-rate was extremely high (to 40% on unburnt slash) two months after sowing but dropped to about 10% on all plots at the end of winter. Thereafter the rate dropped to about 2% on mineral soil but remained at 7-10% on slash plots.

Sowing in October '56. Early death-rates were much lower on all plots. To some extent this was due to a thinning-out of fireweed. Two months after sowing the death-rate was about the same on all seed-beds (12-14%) and thereafter remained at that rate on slash plots but dropped to a mean of about 6% on mineral soil.

3. GAP EXPERIMENT (Exper.3)

The rate of deaths on the various gaps and under full canopy are shown in Table 3.14 and Fig. 3.10.

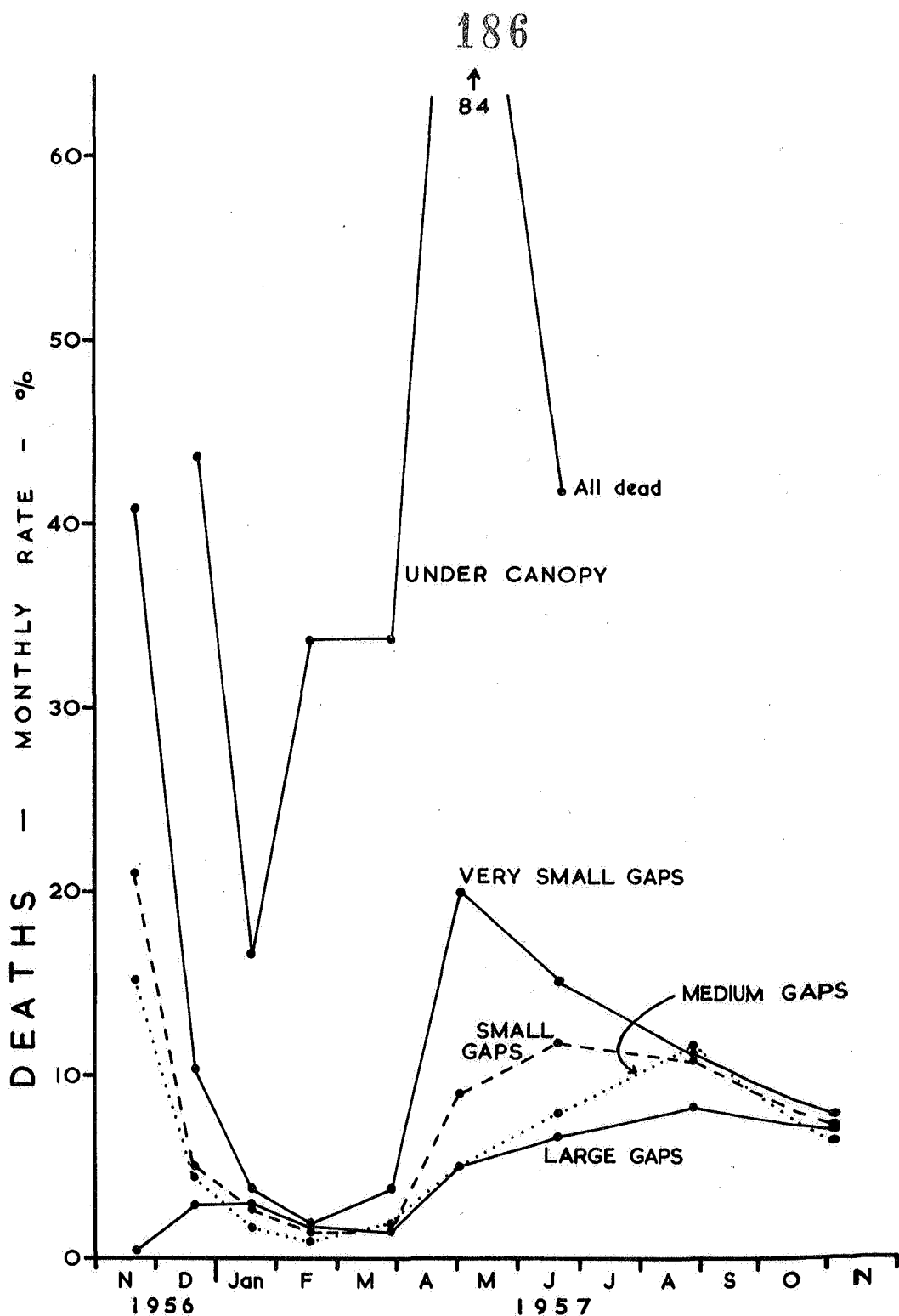


Fig. 3.10. MONTHLY RATE OF DEATHS IN GAPS of various sizes and beneath an undisturbed understory canopy. Relative to the open, the amount of light received in each gap was large $\frac{1}{2}$, medium $\frac{1}{4}$, small $\frac{1}{8}$, very small $\frac{1}{16}$ and under the canopy $\frac{1}{50}$ - $\frac{1}{100}$. Each point represents the total death-rate on thirty-two 2 x 2 ft sub plots - eight in each of four replicates of each size of gap, but under the canopy there were only eight 2 x 2 ft. plots. Eucalyptus regnans Road 10, Florentine Valley.

TABLE 3.14

Death-rate of seedlings- % per month
(% of seedlings alive at previous scoring)
E.regnans. Gap Experiment (3) Road 10.
 Dates are middle of scoring periods.
 Seed sown 11.10.56.

DATE	GAP SIZE				
	Large	Medium	Small	V.Small	Under Canopy %
8.11.56	First Scoring				
21.11.56	0.3	15.2	20.9	40.7	
21.12.56	2.8	4.5	4.9	10.2	43.5
18. 1.57	2.9	1.7	2.7	3.9	26.6
17. 2.57	1.6	0.8	1.4	1.9	33.7
27. 3.57	1.4	1.9	1.4	3.8	33.7
1. 5.57	5.1	5.1	9.2	20.0	84.2
20. 6.57	6.7	8.4	11.9	15.2	41.7
26. 8.57	7.9	11.6	10.8	11.2	All
3.11.57	7.0	6.4	7.3	8.5	Dead
Light relative to open.	1/2	1/4	1/8	1/16	1/50

Seed sown 19.10.56. Germinations nil on 8.11.56.

In large gaps the death-rate was very low through the first spring and summer, even at the cotyledon stage 6 weeks after sowing. As gap-size diminished the initial death-rate increased considerably - large gaps 0.3%, medium 15.2%, small 20.9%, very small 40.7%, and with the sowing under the full canopy, 43.5%; but thereafter the rate of deaths in all gaps (but not under the full canopy) remained low throughout the summer. There was a marked increase in the death-rate through the winter and spring with no marked differences between gaps. In large gaps the growth of fireweed was much stronger than in smaller gaps and it was in the large gaps that seedlings up to 9 ins. high rotted away among dense fireweed. Under the full canopy all seedlings had died by the end of June.

The major part that fungi can play in determining the establishment of young eucalypt seedlings in regions such as the Florentine was clearly seen on these plots. Soil-moisture was never limiting but reduced light intensities seemed to affect the death-rate, probably by causing seedlings to be "soft" and etiolated.

4. SOWINGS OF TREATED SEED (Exper.4)

Seed treatment had no effect on death-rate so all treatments are lumped to give the data of Table 3.15.

TABLE 3.15 Death-rate of seedlings - % per month (% of seedlings alive at last scoring) E.regnans.
Seed treatment experiment (4) Boggy Creek.

Dates are middle of scoring period.

Seed sown 19.9.56. First scoring 2.11.56

<u>10.11.56</u>	<u>27.11.56</u>	<u>22.12.56</u>	<u>18.1.57</u>	<u>12.2.57</u>	<u>27.5.57.</u>
16.2	45.0	3.8	4.3	4.6	6.4

Again there was a high death-rate (45%) at the cotyledon stage during a period of high rainfall and then the death-rate declined to less than 5% through the summer. The rate of 6.4%, for a period of 140 days centred around the 27th May, probably consists of a lower rate during the autumn and a higher rate during the early winter.

VI NUMBER OF GERMINATIONS IN THE FIELD AND TREE PERCENT.

In Table 3.16 are shown the number of germinations in the field according to the condition of the seed-bed and the protection given against seed-harvesting insects. The numbers of viable seed per pound used to calculate germination percentages in the field were based on laboratory germination and cutting tests.

In the case of the plots at Road 10 (Exper.3), the establishment and development of seedlings was of primary importance and the rate of germination secondary. Therefore no great care was exercised in defining the limits of the buffers around the 2 x 2 ft. plots and sowing-rates on the plots themselves may have been higher or lower than planned, as the buffer was 75% of the area of plot plus buffer. Even if the sowing-rate on the plots themselves was higher than intended, the numbers of germinations (per pound of seed sown) for these plots were remarkably high - from 54,000 for small gaps to 104,000 for large gaps. In any case the rates of survival of germinates are not open to this criticism.

Jacobs (1955) states that a tree per cent (established seedlings per 100 seeds applied) of 1.0 is low by world standards and 0.1% is very low and doubts whether "an average higher than 0.1% for the smaller seeded species (eucalypts) will be obtained in normal forest operations." Before considering the results obtained on the plots in the Florentine it must be stressed that large numbers of seedlings, especially on the "younger" plots, were far from being

TABLE 3.16 No. of germinations in the field and survival of
E. regens. **Florentine Valley.**

PLOTS	SOWN	STED BED	INSECT CONTROL	GERMINATIONS		Date	SURVIVAL	
				Per lb.	% of Viable Seed		% Total Germin- ations	% of Viable Seed
Lords	19.10.55	Mineral Soil	Sprayed	25,500	15.5	10.10.57	38.6	6.0
		-	-	14,750	8.9		23.8	2.1
		Burnt Slash	Sprayed	12,000	7.3		18.5	1.3
		-	-	1,960	1.2		13.0	0.2
		Unburnt Slash	Sprayed	4,900	3.0		11.0	0.3
		-	-	2,780	1.7		15.3	0.3
	13. 4.56	Mineral Soil	Sprayed	23,000	14.4	10.10.57	39.8	5.7
		-	-	7,230	4.5		30.6	1.4
		Burnt Slash	Sprayed	15,200	9.5		14.3	1.4
		-	-	1,930	1.2		7.4	0.1
		Unburnt Slash	Sprayed	5,700	3.6		9.0	0.2
		-	-	570	0.4		0.0	0.0
	11.10.56	Mineral Soil	Sprayed	26,700	19.1	10.10.57	46.8	8.9
		-	-	11,050	7.9		53.2	4.2
		Burnt Slash	Sprayed	29,700	21.2		27.1	5.7
		-	-	8,900	6.4		7.6	0.5
		Unburnt Slash	Sprayed	14,500	10.4		25.0	2.6
		-	-	2,200	1.6		11.4	0.2

NOTE: # number of above sprayed plots were fenced.

TABLE 3.16
(Cont.)

No. of germinations in the field and survival of
E. regens. Florentine Valley.

PLOTS	SOWN	SEED BED	INSECT CONTROL	GERMINATIONS		SURVIVAL	
				Per lb. Viable Seed	% of Viable Seed	Date	% Total Germinations % of Viable Seed
Road 7 Broadcast	7.11.55	Various	-	3,100	2.6	20.11.57	17.5 0.5
	16. 4.56	Various	-	2,270	1.9	20.11.57	17.4 0.3
Road 10 Gaps: Large Medium Small V. Small Under Canopy:	11.10.56	Cultivated	Sprayed	104,000	71.4	11.12.57	49.9 35.6
		"	"	69,500	48.9	"	43.6 21.3
		"	"	54,200	38.7	"	36.5 14.1
		"	"	54,900	39.2	"	25.1 9.8
	19.10.56	As Layer	-	29,300	20.9	26. 5.57	0.0 0.0
NOTE: Plots Fenced							
Bossy Ck.	19. 9.56	Mineral Soil	Dusted D.D.T. Steeped Dieldrm.	57,500	47.9	26. 7.57	51.2 24.6
				35,800	29.9	"	51.7 15.4
				33,900	28.3	"	51.7 14.6
Road 11	20.11.57	Mineral Soil	Dusted D.D.T.	17,200	14.8		
		Burnt Slash		15,500	13.3		
		Unburnt Slash		8,630	7.4		

6 Plots 2'x 2' with 1' surrounds. Errors probable in rate of seedling - see text

TABLE 3.17

Survival of seedlings given as the
% of number of viable seed sown on
plots neither fenced nor sprayed.

E. regnans. Florentine Valley

LOTS	SEED BED	MONTHS SINCE SOWING	SURVIVAL % OF NO. VIALE SEED SOWN
LORDS	Mineral Soil	24	2.1
	Burnt Slash	"	0.2
	Unburnt Slash	"	0.3
	Mineral Soil	18	1.4
	Burnt Slash	"	0.1
	Unburnt Slash	"	0.0
	Mineral Soil	12	4.2
	Burnt Slash	"	0.5
	Unburnt Slash	"	0.2
ROAD 7	Various	24	0.5
	Various	18	0.3
ROAD 10 Under Canopy	As Layer	7	0.0
BOGOY CREEK	Mineral Soil	10	14.6

"established" at the time of the last inspection.

Sowings on mineral soil, especially when the seed-bed was cultivated, gave very good results (minimum of 17,000 germinations per pound) but the very high survival rates are for "young" plots which had been given protection from insects and marsupials. The poor results to be expected on inferior seed-beds and without protection are shown by Table 3.17, where for scorings 12 months or more after sowing only plots on mineral soil had survival rates above 1% (based on the number of viable seed sown). On slash plots at Lords (Exper.1), 12-18 months after sowing, the seedlings which had survived represented no more than 0-0.5% of the number of viable seed sown.

For experiment 1 (Lords) the mean number of germinations on plots sown at a rate of 4 lbs. per acre was about twice the number for sowings at 2 lbs. per acre. The ratios for the three times of sowing ranged from 1.70 to 2.20 with a mean of 1.88 - Table 3.18.

TABLE 3.18 Total number of germinations of *E. regnans* on plots at Lords (Exper.1) according to the rate of sowing.
Each figure is the total for 9 plots - 3 on each of the seed beds - mineral soil, burnt slash and unburnt slash. Plots 16 x 16 ft.

SOWING	RATE OF SOWING LBS/ACRE		RATIO b/a
	(a) 2 lbs.	(b) 4 lbs.	
19.10.55	1297	2484	1.92
13. 4.56	1071	2361	2.20
11.10.56	2184	3714	1.70
TOTALS:	4552	8559	1.88

PART FOUR

DEVELOPMENT

OF THE

YOUNG SEEDLING

AND

THE EFFECT OF BROWSING

DEVELOPMENT OF THE YOUNG SEEDLING AND THE EFFECT OF BROWSINGI. GENERAL

The highest percentage of germinations occurs on cultivated soils free of weed species. During wet seasons early survival is greatly affected by fungal attack. This leads to heavy losses of small seedlings growing among dense "stands" of weed-species. Development in the first two years is slowed down by competing vegetation. However, provided the seedlings survive attacks by fungi, browsing by native animals has the most serious effect on growth.

II. EARLY HEIGHT GROWTH

The general picture from all sowings is one of slow initial growth. Under certain circumstances (overseas plantings with freedom from leaf-eating insects is one) the early growth of eucalypts can be extremely fast but for the many and varied sowings made in the Florentine some of the absolute maximum height growths recorded were:-

Lord's Plots:

Sown Oct. '55:	86 ins. in April '57.	114 ins. in Dec. '57
Apr. '56:	22 ins. " " '57.	44 ins. " " '57
Oct. '56:	7 ins. " " '57.	27 ins. " " '57

These seedlings were all on mineral soil, the best on other seed-beds being a seedling 19" high on unburnt slash

14 months after sowing. In the gap experiment on cultivated soil the tallest seedling on the 128 plots, after 9 months, was 18 ins. With the spot-sowing trials at Road 7, the best seedling on 448 spots was 8 ins. 3 months after sowing, and another was 18 ins. at the end of 5 months; both after sowings in November.

In Tables 4.1 and 4.2 are shown the mean heights of the four tallest seedlings on each of the fenced plots at Lords and in the gap experiment.

On less favourable sites growth is much slower and large numbers of seedlings have no more than a poorly developed first pair of leaves, 18 months or more after sowing. Not many of such seedlings are likely to remain alive. In addition many of the better seedlings are heavily browsed, so that in the early stages of natural regeneration of eucalypts on coupes in the Florentine seedlings appear to be absent or very few in number. It may take as long as five years for seedlings on a coupe to overcome fireweed competition and recover from browsing and so reach the stage where a superficial inspection is sufficient to indicate that eucalypt regeneration has become established.

TABLE 4.1 Heights (ins) of E. regnans seedlings on fenced plots at Lords.
Two plots in each cell. Each figure mean of 4 tallest
seedlings per plot.

SOWN	MEASURED	SEED BED			
		Mineral Soil	Burnt Slash	Unburnt Slash	
Oct. '55	Apr. '57	42	15	8.5	16
	Dec. '57	55	26	19	32
Apr. '56	Apr. '57	11	5	4.5	5
	Dec. '57	26	3	13	10.5
Oct. '56	Apr. '57	5.5	1	< 1	4
	Dec. '57	15.5	3.5	< 1	11

TABLE 4.2 Heights (ins) of E. regnans seedlings on fenced plots in gap
experiment. Road 10. Seed sown 11.10.56. measurements made
26.7.57. For each replicate, height is mean of the largest
16 seedlings.

GAP SIZE & REPLICATES															
LARGE				MEDIUM				SMALL				V. SMALL			
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
5.9	7.5	4.9	1.9	4.6	5.2	5.0	3.9	4.3	2.4	8.4	5.4	3.1	2.9	5.2	1.3
MEANS: 5.1				4.7				4.6				3.1			

III. THE EFFECT OF BROWSING

1. On the basis of observations made of living plants it is apparent that in the Florentine, all forest species, even sometimes ferns, are browsed by native animals (marsupials). Greater populations of most of the browsing marsupials occur in and around sedgelands than in the virgin forest but it is not known whether all species of the sedgelands are browsed.

In the forest areas some assessment of the magnitude of the effect of browsing has been made but no investigation has been undertaken into the species of browsing animals, their populations and breeding, their food preferences, their movements and other problems. Some general observations have been made on some of these aspects and hunters have supplied impressions and information obtained from many years experience in trapping and snaring.

In the undisturbed virgin forest, populations of ground-living, browsing marsupials are very small as would be expected from the paucity of broad-leaved seedlings, and confirmed by the virtual absence of trails, dung or browsed plants. But when the forest is less dense, such as near sedgeland, or above 2500' on mountains the animal numbers are much higher. It is not known how the populations of 'possums vary with the type of forest but Guiler (1957) states that Pseudocheirus convolutus (ringtail possum) which is found throughout Tasmania may not occur in areas of rain forest.

Undoubtedly the overall position is one of balance between the plants and animals of an area but at certain times the balance can be radically upset by sudden changes and such

changes are obvious in the case of wild fires and logging. But in these two cases the changes in plant-animal relationships are in opposite directions.

The overall population of browsing animals in the virgin forest is at a low level, with increases in density around locally attractive areas. When several thousand acres of forest are destroyed by fire enormous numbers of seedlings soon become available to the animals but the area of the burn is so large that only a small build-up can take place in the number of browsing animals per unit area. In this, and other respects, the widespread wild-fire creates conditions favourable for the development of seedlings of tree species. It is most unlikely that a build-up in animal numbers by breeding, in addition to the influx from other areas, could occur quickly enough to have any appreciable effect on the development of seedlings on large burns. After two or three years, tree species will have grown away from maximum browsing hazards. Ringbarking of trees has not been seen in the Florentine and would be unlikely to be brought on by a lack of the animals' usual foods. Snow is short-lived and the wholesale death by drought of the seedlings of trees and shrubs would be most unlikely. In the Florentine it was not apparent that the animals found eucalypt seedlings to be less palatable than those of other species. On devastated forest areas near Maydena, frequent disturbances of the site by logging and burning have allowed grass to become established. Here, eucalypt seedlings appear to enjoy some immunity from browsing probably because they are relatively less palatable than grass.

On the relatively small coupes in the Florentine (20-40 acs.) (and in fact on cut-over areas generally) animal numbers are built up by movement from the surrounding areas

of low density but the coupe area is so small that the influx has a most marked effect on regeneration of plants. As logging proceeds there will be an increasing number of animals because of the increasing amount of food available along roadsides and on cut-over areas. Browsing on future coupes is likely to be more intensive than on present coupes. The impact of browsing animals attracted to small forest openings was demonstrated by Dr.D.Ashton of the Botany Department, University of Melbourne, in natural and artificially created small openings in E.regnans forest in Victoria. Within a few years after clearing, fenced plots appeared as 10'-15' high tufts, among vegetation kept to a height of about a foot by marsupials.

2. BROWSING ANIMALS

Following Guiler (1957) the nomenclature used is that of Iredale and Troughton (1934). The animals which will be discussed are the wallabies (Wallabia and Thylogale), the possums (Trichosurus and Pseudocheirus), the wombat (Phascogale), other marsupials and the rabbit (Oryctolagus).

Bennett's Wallaby (in Tasmania usually called kangaroo)
Wallabia rufogrisea v. bennetti.

Thylogale (in Tasmania usually called wallaby) Thylogale billardieri.

It is probable that these two animals cause more damage to seedlings than any others, particularly on coupes which are more completely "cleared" than others. Both are largely nocturnal, spending most of the daylight hours in the adjoining uncut forest. They tend to keep to areas of easier movement and so their greatest effect is on developing

vegetation along logging tracks. Dense clumps of fire-weeds, as an example, give protection to seedlings of tree species.

Nothing is known of population densities but it could be low even on areas attractive to them - the density in uncut forest is probably very low. Hunters report that in snaring around a coupe, catches are reasonable for a week or two and then become almost nil and this is attributed to the animals being scared away. If snaring ceases for a while the kangaroo and wallaby return but it is equally possible that the fall in catch is due to exhaustion of numbers and the return is in fact a restocking by different animals.

Brush Possum. Trichosurus vulpecula.

While Wallabia and Thylogale are probably entirely herbivorous, Trichosurus is omnivorous but plants appear to provide the bulk of its food. It spends some time on the ground but Pracy & Kean (1949) report that in New Zealand, where Trichosurus has been introduced, the time spent on the ground is largely concerned with moving from tree to tree along fairly well defined trails.

The plots at Lords are on an area on which almost all trees have either been felled or knocked down during logging and signs of Trichosurus were not often observed. If they moved across the area from one uncut edge to the other, feeding but little as they travelled, then the complete absence of browsing inside fenced plots would be explained. On the other hand in the gap experiment there is good evidence of browsing by Trichosurus. All the 2' x 2' plots were enclosed in small 3.5 ft. high cylinders of $1\frac{1}{2}$ in. mesh wire netting. Ten months after sowing the seedlings on most plots were heavily browsed by Trichosurus, presumably

owing to the smaller area of the gaps in the forest.

Ringtail Possum. Pseudocheirus convolutor.

No certain signs of this possum have been found in the vicinity of the plots and this is to be expected if the suggestion of Guiler (1957) is correct that ringtails do not inhabit rain-forest areas. In any case most of their time is apparently spent above the ground and damage is caused to saplings (chewing of young shoots) rather than to seedlings.

Wombat. Phascogalemys ursinus.

Wombats do not appear to be present in the forest of the Florentine except near the sedgelands on Tim Shea and the remnants of the grasslands in the central Florentine. They may check the development of seedlings in localized areas but for the better quality forests need not be considered.

Other Marsupials.

A limited amount of scratching and rooting has been observed which could be attributed to one or more of the smaller marsupials. The extent of their browsing is not known but very small seedlings are sometimes scratched out or buried. In the case of the plots at Lords the fences were intended to keep out kangaroo and wallaby and many small gaps existed below the bottom of the netting because of the uneven ground and the presence of logs. Although many of the small marsupials could have got into the fenced plots no sign of browsing or scratching was observed within the fences.

Rabbit. Oryctolagus cuniculus.

No signs of rabbits have been seen in the central Florentine.

3. THE ONSET OF BROWSING.

The onset of browsing is more dependent on the attainment of a certain size by the eucalypt seedling than on the lapse of time i.e. seedlings have to become "browsable". It will be shown that another factor involved is the accessibility of the seedling to the animal. Table 4.3 shows the time which elapsed before browsing commenced on various plots.

TABLE 4.3 Commencement of browsing on seedlings of
E.regnans on plots in the Florentine Valley

PLOTS	SOWN	BROWSING COMMENCED
Lords, on mineral soil	October '55 April '56 October '56	early April '56 Dec. '56 - Jan. '57 October '57
Spot-sowing trials	November '55 April '56	end April '56 April '57
Gap experiment	October '56	Sept. '57 (brush possum)

Except in the case of the gap experiment, kangaroo and wallaby were responsible for the browsing. Browsing was not recorded in less than six months after sowing but may not occur for twelve months if seedling growth is slow and/or protection is given by weed-species.

For the spot-sowing trials at Road 7A, each of the 933 spots was scored according to the greatest number of pairs of leaves on any seedling and as to whether browsing had occurred on the spot - see Table 4.4. Nominally the

TABLE 4.4 Number of spots on which seedlings of *E. reginae* had been
browsed, according to development of best seedling on each spot.
Spot sowing trial, Road 7A, Florentine Valley. Scored 20.11.57

SOWING & PLOT NO.	No. of Pairs of Leaves														FAILED SPOTS	TOTALS
	< 2		2		3		4		5		> 5					
	Br	No	Br	No	Br	No	Br	No	Br	No	Br	No				
7.11.55																
1/2	2	65	2	17	5	15	12	6	5	1	6	-			1	137
2/4	-	47	-	4	6	6	8	2	4	-	12	1			-	90
3/2	-	52	1	4	4	5	18	3	3	-	12	-			3	105
4/4	1	40	2	5	13	5	13	6	6	-	17	4			3	115
TOTALS: Browsed	3	204	5	30	28	31	51	17	18	1	47	5			7	447
	1%			14%		47%		75%		95%		90%				
12.4.56																
1/1	-	28	3	18	8	20	5	10	4	3	9	2			3	115
2/3	1	69	1	26	3	12	1	4	4	3	1	-			6	153
3/4	-	45	3	21	4	8	5	2	3	-	4	-			6	106
4/2	-	40	3	20	12	11	6	8	4	5	1	-			2	112
TOTALS: Browsed	1	202	15	85	27	51	20	26	15	11	14	2			17	486
	-			15%		35%		43%		58%		89%				
GRAND TOTALS: BROWSED	4	406	20	115	55	82	71	43	33	12	61	7			24	933
	1%			15%		40%		62%		73%		90%				

Br - Browsed No - Not browsed

scoring was at 20.11.57 (sowings Nov. '55 and April '56) but the scorings include spots on which all seedlings had died; these spots being scored according to their condition before the death of the seedlings. As deaths tended to occur earliest on the spots where seedling development was poor it is possible that the low rate of browsing of small seedlings is due to the short time that many of them were exposed to browsing. However, a scoring of the November '55 plots which was made in August '56 (15 months earlier than the time for which the data of Table 4.4 was compiled) indicated a position not radically different from the later inspection - see Table 4.5.

TABLE 4.5 Number of spots on which seedlings of *E. regnans* had been browsed according to the development of the best seedling on each spot.

Spot-sowing trials, Road 7A, Florentine Valley.
Sown 7.11.55 Scored 27.8.56 and 20.11.57

SCORED	NO. OF PAIRS OF LEAVES					
	< 2	2	3	4	5	> 5
27. 8.56	0	2.5	43	71	67	84
20.11.57	1	14	47	75	95	90

It is obvious from the two tables that absolute size (which may be bulk and not height) largely governs the probability that browsing may occur. With 5 pairs of leaves the chance of browsing reaches between 60-90%.

4. REDUCTION IN SEEDLING NUMBERS DUE TO BROWSING

Fencing had no effect on the number of germinations on the plots at Lords but the condition of the seed-bed and spraying had such marked effects that comparisons between plots of the effect of browsing on absolute seedling-numbers is not possible. However direct comparisons can be made of the rate at which the number of seedlings alive at the time of one scoring had died before the time of the next.

(1) LORD'S PLOTS - SOWING 19/10/55.

The Monthly Death-rates of regnans seedlings, according to the condition of the seed-bed and the "animal" treatment applied are shown in Table 4.6 and Fig. 4.1.

(a) Mineral Soil.

Five months after sowing the effect of browsing became very evident on the unfenced plots on mineral soil (Fig. 4.1). Up to this time the death-rate had been of the same order on all plots - varying from about 7% - 14%, but when the eucalypt seedlings became large enough to be browsed the death-rate jumped to 20% on unfenced plots compared with 5% on the plots protected from animals. Except for a period of one month during the winter following sowing the death-rate remained much higher on the unfenced plots and during almost the whole of the second year after sowing remained above 7% compared with 0.5% to 2.0% on the fenced plots.

The continued higher rate of death on unfenced plots during the second year was due in part to seedlings dying after being re-browsed following recovery from the initial attack and in part to the browsing for the first time of seedlings which had made slow growth or had earlier been protected by vegetation less palatable to the animals.

(b) Burnt Slash.

It is obvious that at the end of two years

TABLE 4.6

DEATHS - % per month (% of seedlings alive at previous scoring) E. regnans Lord's Plots.

Each number is mean for 2 plots, each 16 x 16 ft.

Sown 19.10.55.

FIGURE 4.1

DAY & MONTH.	MINERAL SOIL			BURNT SLASH			UNBURNT SLASH		
	F&S	S	U	F&S	S	U	F&S	S	U
25/12	11.1	14.4	12.2	30.4	15.8	27.3	23.8	15.6	5.4
21/1	7.2	6.8	7.7	20.5	18.9	22.7	17.6	14.8	14.9
18/2	9.2	11.6	9.1	30.3	24.5	26.8	28.3	21.4	10.4
18/3	5.1	20.6	22.0	12.9	12.7	5.4	16.3	11.4	7.5
19/4	3.5	11.9	12.6	12.8	19.0	6.9	16.0	13.7	24.2
23/5	4.2	17.2	14.9	11.2	14.0	4.8	13.5	9.9	10.3
27/6	6.3	12.5	13.5	6.2	13.3	6.8	14.1	12.9	15.1
28/7	7.0	7.3	9.1	11.7	5.4	15.7	13.5	16.5	6.3
31/8	4.7	16.6	9.0	7.1	13.1	11.5	11.4	14.2	20.3
20/10	1.9	9.0	12.6	9.5	3.3	6.7	9.1	16.1	11.9
6/12	1.2	8.4	14.3	4.4	12.7	-	14.8	3.2	-
5/1	1.2	8.2	9.0	4.5	2.9	4.6	10.4	4.8	-
3/1	0.6	6.1	7.5	5.9	3.4	6.4	8.1	4.2	1.7
11/7	0.7	6.4	8.2	1.4	4.3	5.9	4.7	7.2	5.2

F&S - Fenced & Sprayed
 S - Sprayed
 U - Untreated

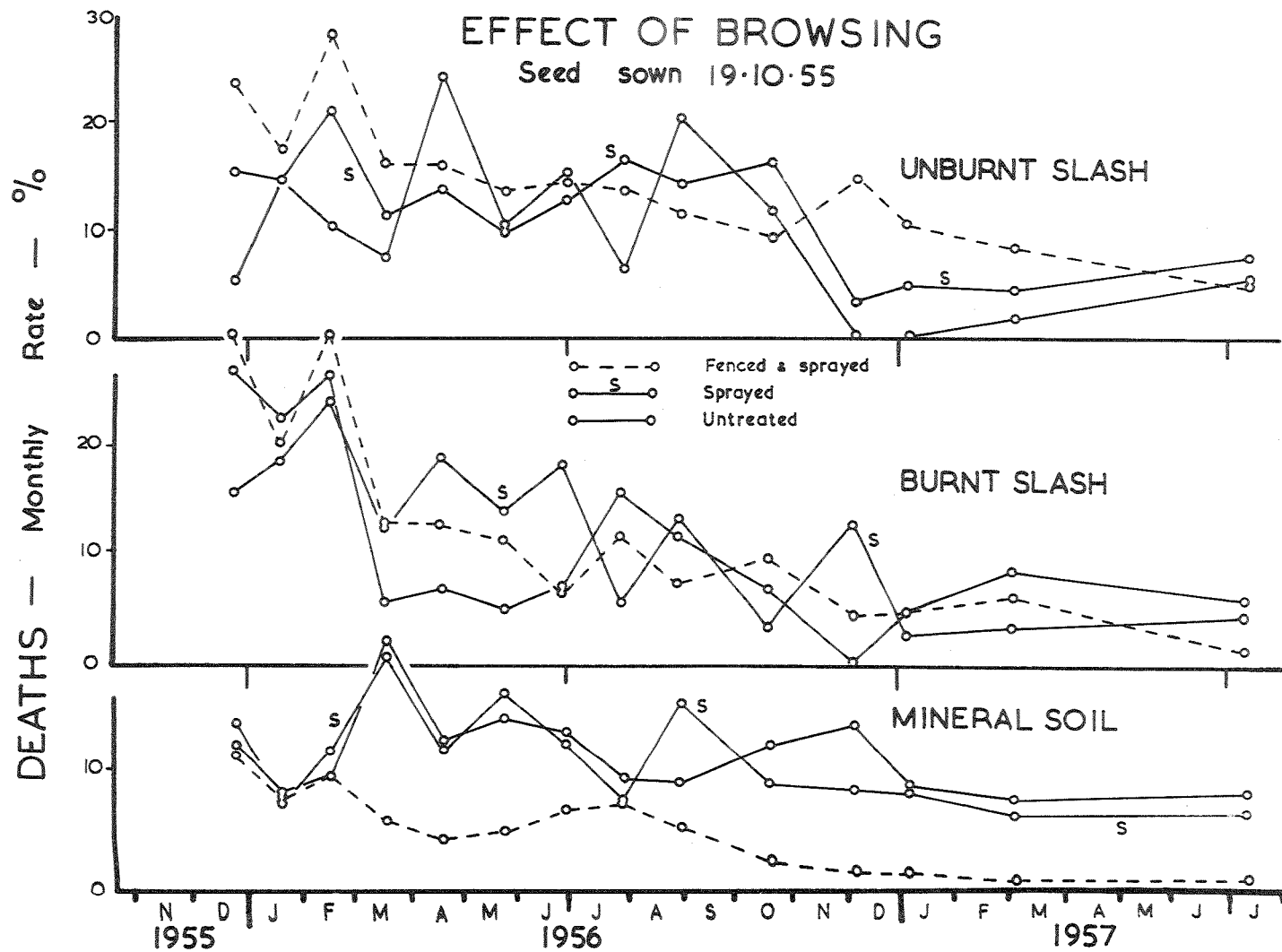


Fig. 4.1. THE EFFECT OF BROWSING. The monthly death-rate of *regnant* seedlings on fenced and unfenced plots at Lords. Spraying designed to reduce losses of seed to insects and would be unlikely to affect browsing. Each point is total for 2 plots. Plot size 16x16ft. Seed sown 19.10.55.

fencing had had no statistically significant effect on the rates of death of seedlings on plots on burnt slash - Table 4.6 and Fig. 4.1. The massive components of the slash and the fireweed which grew after burning constituted sufficient barriers to animal movement to protect the seedlings.

But in the autumn of 1957 the important component of the fireweed growth, Erechthites, reached its lowest density-level since the time of sowing and the eucalypt seedlings, many now big enough to be browsed, were exposed to the animals. The death-rates during the winter of 1957, of 1.4% on fenced plots and 5% on unfenced plots, are not statistically significant departures from the preceeding pattern, but nevertheless reflect the first observable effects of browsing. Another measure of this effect, the height of the seedlings, is given and discussed in the section dealing with the effect of browsing on height-growth.

(c) Unburnt Slash.

On these plots the slash itself hindered animal movement but again it was a decrease in the density of the weed-species which allowed browsing to occur and this was followed by an increase in the death-rate of eucalypt seedlings on unfenced plots compared with fenced plots. Generally the position on the plots on unburnt slash was similar to that on burnt slash.

The Percentage Survival of Seedlings.

The data (inter alia) are summarized in Table 4.7 by "animal" treatments and seed-beds. This table sums the periodic losses shown in Table 4.6 and shows the overall difference in the effect of fencing on each seed-bed. Two years after sowing there were insignificant increases in the survival of seedlings on fenced slash-plots but a most marked increase on the fenced plots on mineral-soil. The ratios of

TABLE 4.7

Lord's Plots. The total number of germinations of *E. regnans* and the percentage remaining alive on 10.10.57.
Plots 16 x 16 ft.
Two plots on each seed-bed for each treatment for each sowing.

SOWING & TREATMENT	SEED BED					
	MINERAL SOIL		BURNT SLASH		UNBURNT SLASH	
	Germin- ations	Alive Survival %	Germin- ations	Alive Survival %	Germin- ations	Alive Survival %
19.10.55 Fenced & Sprayed Sprayed Untreated	1000 836 520	57.1 16.5 11.9	334 516 69	68 89 9 13.0	174 172 98	20 18 15 11.6 10.5 15.3
13. 4.56 Fenced & Sprayed Sprayed Untreated	829 797 255	49.1 30.0 30.6	579 492 68	68 65 5 15.2 13.2 7.4	283 119 20	31 5 - 11.0 4.2 0.0
11.10.56 Fenced & Sprayed Sprayed Untreated	786 1092 389	430 453 207 54.7 41.5 53.2	952 1158 316	301 271 24 31.6 23.4 7.6	492 535 79	147 110 9 29.9 20.6 11.4

the percentage of survivals on fenced to the percentage on unfenced plots were 3.9 on mineral soil, 1.2 on burnt slash and 1.0 on unburnt slash.

(11) LORD'S PLOTS - SOWING 13/4/56.

The Monthly Death-rates are shown in Table 4.8 and Fig. 4.2.

(a) Mineral Soil.

The effect of browsing on these plots is not as spectacular as on similar plots sown in October '55 but the seedlings on the plots now being considered are 6 months younger.

Browsing of eucalypt seedlings was first noticed in December '56 and although the differences between plots are not significantly different they are in fact a reflection of differences of biological significance. In terms of the survival of all germinants, 49% survived on fenced plots and 30% on unfenced plots (Table 4.7).

The differences are expected to increase. Seedlings arising from sowings in April almost immediately experienced a period of slow growth (through the winter) and so the onset of browsing was delayed because of the smallness of the seedlings. In addition, for these particular sowings the increased growth of weed species, although slight, was sufficient to give some protection not enjoyed by seedlings germinating on similar seed-beds six months earlier.

(b) Burnt Slash.

Regnans seedlings were browsed on the plots on burnt slash but no significant effect is evident in the pattern of death-rates (Fig. 4.2) or in the percentage of total germinations which had survived 18 months after sowing - fenced plots 15.2%, unfenced 12.5% (Table 4.7)

TABLE 4.8

Deaths - % per month (% of seedlings alive at previous scoring). E. regnans. Lord's Plots.
Each figure is mean for 2 plots, each 16 x 16 ft.
Down 13.4.56 FIG. 4.2

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STED	BED	TREATMENT	DAY & MONTH - MID-PERIOD BETWEEN SCORINGS									
			23/5	27/6	28/7	31/8	20/10	6/12	5/1	3/3	11/7	
Mineral	Soil	Fenced & Sprayed	10.2	18.6	18.2	6.3	4.8	2.0	2.5	1.5	2.2	
		Sprayed	9.5	31.6	20.9	9.4	10.2	17.4	4.6	3.6	3.8	
		Untreated	5.9	11.8	13.1	7.2	5.8	-	6.9	5.4	7.5	
Burnt	Slash	Fenced & Sprayed	21.3	24.3	12.8	8.3	11.4	17.6	11.0	10.8	7.0	
		Sprayed	13.7	31.6	18.5	12.3	15.9	21.2	19.8	10.5	5.6	
		Untreated	18.8	25.4	20.5	-	11.5	18.6	3.0	20.4	10.1	
Unburnt	Slash	Fenced & Sprayed	42.6	34.8	20.3	7.0	15.3	4.4	4.7	10.4	7.5	
		Sprayed	25.3	48.0	18.9	15.0	7.6	9.9	19.3	16.7	11.0	
		Untreated	17.2	48.9	29.4	44.1	29.8	-	-	100.0	-	

EFFECT OF BROWSING

Seeds sown 13.4.56

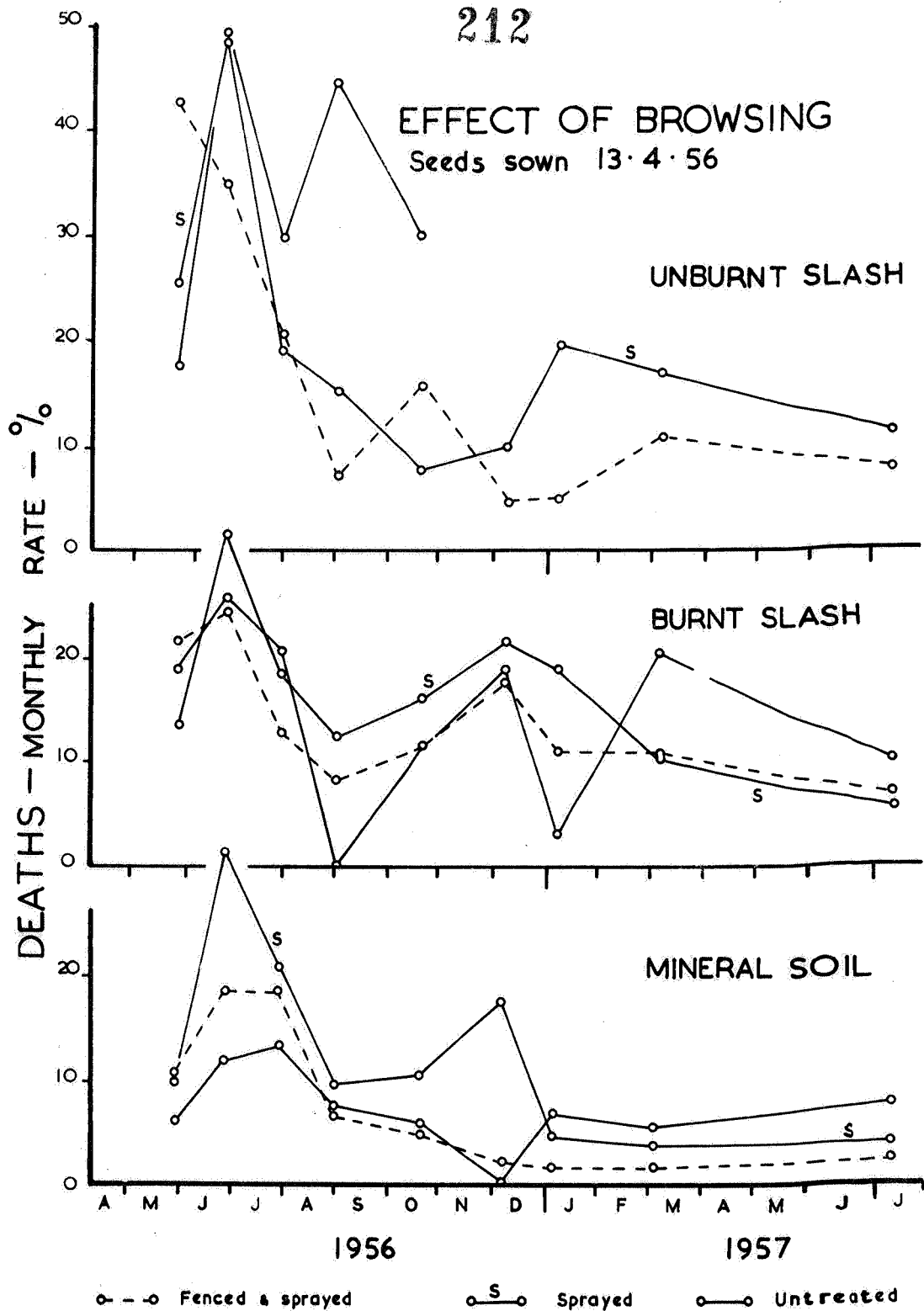


Fig. 4.2. THE EFFECT OF BROWSING The monthly death-rate of *Eucalyptus regnans* seedlings on fenced and unfenced plots at Lords, Florentine Valley. Spraying treatment was designed to reduce losses of seed to insects and would be unlikely to affect browsing. Each point represents total of 2 plots. Plot size 16 x 16 ft. Seed sown 13.4.56. In October '56 only two seedlings remained alive on untreated plot on unburnt slash.

(c) Unburnt Slash.

Differences in the death-rate pattern between fenced and unfenced plots cannot be attributed to browsing. On untreated plots only two seedlings were alive 6 months after sowing - before browsing was likely - and in any case no browsed seedlings were observed on any of the unfenced plots.

(iii) LORD'S PLOTS - SOWING 11/10/56.

The Monthly Death-rates are shown in Table 4.9 and Fig. 4.3.

(a) Mineral Soil.

Browsing was evident on these plots ten months after sowing and the effects were marked at the end of 15 months when the death-rate was below 2% on fenced plots compared with 11% on unfenced. The percentage of survivals shown in Table 4.7 are based on scorings made 12 months after sowing, being 55% on fenced and 44.5% on unfenced plots. Three months later the percentages were 57.7% for fenced plots (increase due to delayed germinations) and 32.6% for unfenced plots.

(b) Burnt Slash.

Field observations did not indicate that browsing had been prevalent on unfenced plots during the first 12 months after sowing. For the last half of this period the death-rate on fenced plots was at about 10% per month while on sprayed but unfenced plots the rate was a little above 15% but the difference is not considered to be attributable to the exclusion of browsing animals; an opinion supported by the drop in the death-rate on unfenced plots from 26% to 5% during the last 3 months.

For the whole period since sowing, 32% of the germinants survived on fenced plots and 20% on unfenced.

TABLE 4.2

Deaths - % per month (% of seedlings alive at previous scoring). W. regnans. Lord's Plots.
Each figure is mean for 2 plots, each 16 x 16 ft.
Sown 11.10.56. FIG. 4.3

SEED BED	TREATMENT	DAY & MONTH - MID-PERIOD BETWEEN SCORINGS									
		6/12	5/1	6/2	17/3	2/6	1/9	13/11	9/1		
Mineral Soil	Fenced & Sprayed	12.4	4.4	4.0	6.8	6.3	5.2	1.4	1.9		
	Sprayed	16.1	4.4	8.8	6.7	5.8	12.0	8.9	13.8		
	Untreated	5.7	8.4	6.7	6.0	5.3	7.1	5.5	7.8		
Burnt Slash	Fenced & Sprayed	17.8	19.5	11.7	13.0	6.9	11.2	9.5			
	Sprayed	7.3	13.8	8.4	12.5	10.6	17.7	16.2			
	Untreated	15.3	13.8	19.0	20.6	13.7	26.5	5.4			
Unburnt Slash	Fenced & Sprayed	19.3	15.3	9.3	16.0	7.6	10.8	3.3			
	Sprayed	8.6	9.1	8.5	12.9	10.7	19.4	13.8			
	Untreated	30.2	10.8	16.7	16.2	18.5	15.4	14.5			

EFFECT OF BROWSING Seed sown 11.10.56

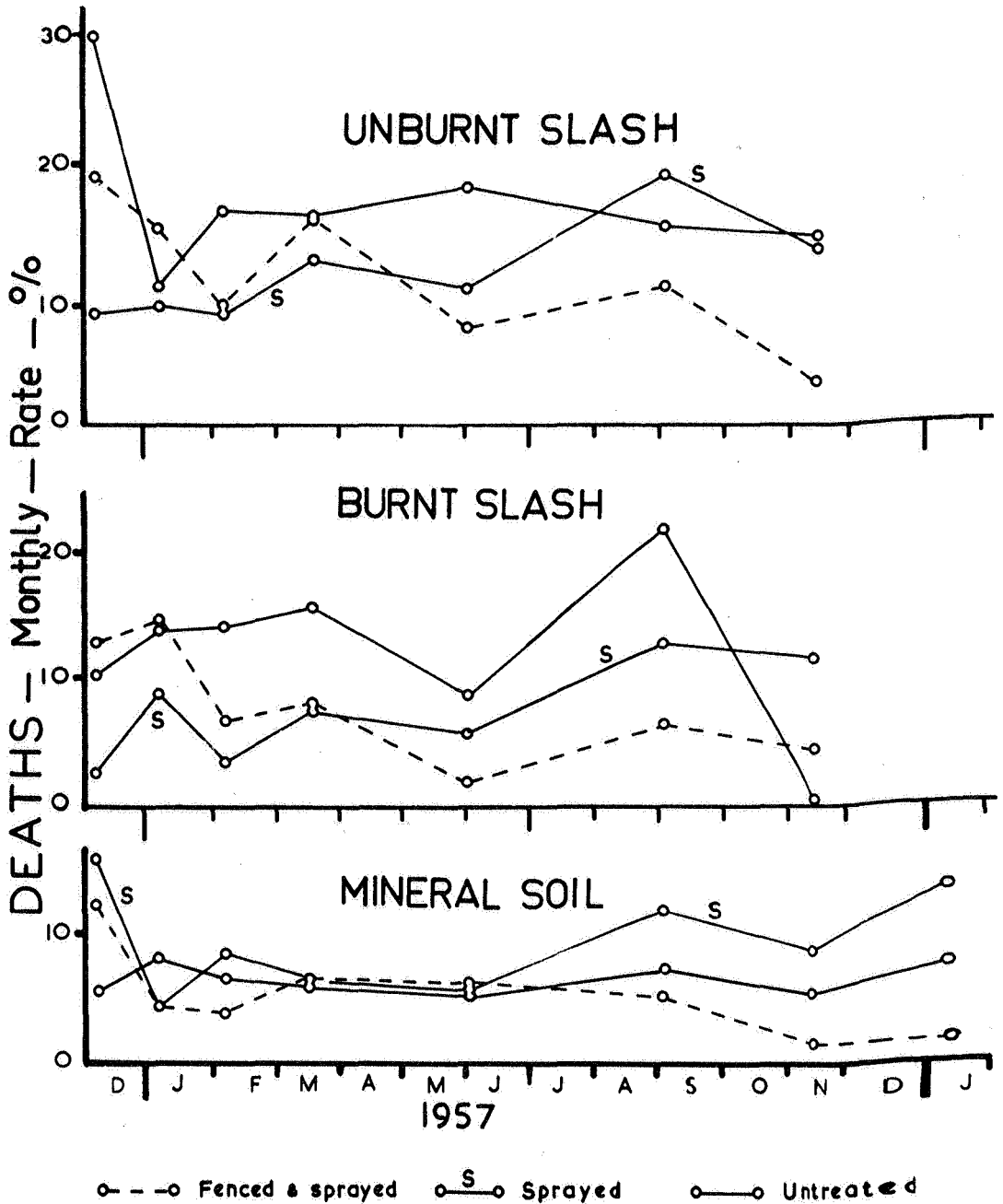


Fig. 4.3. THE EFFECT OF BROWSING. The monthly death-rate of *Eucalyptus regnans* seedlings on fenced and unfenced plots at Lords, Florentine Valley. Spraying treatment was designed to reduce losses of seed to insects and would be unlikely to affect browsing. Each point represents total for 2 plots. Plot size 16 x 16 ft. Seed sown 11.10.56.

(c) Unburnt Slash.

Six months after sowing the death-rate on the fenced plots sharply declined to become less than the rate on the unfenced plots. Although scrub species were browsed on the unfenced plots, the regnans seedlings were generally too small to be affected and the exclusion of animals was not apparently the reason for the reduced death-rate on the fenced plots. In the case of the sowings of October '55 on unburnt slash browsing did not occur until nearly 2 years after sowing.

5. EFFECT OF BROWSING ON THE DEVELOPMENT OF THE SEEDLING

The effect of browsing on the survival of young seedlings of regnans has been discussed and it was seen that the most marked effects were on plots on mineral soil and that on plots on burnt and unburnt slash browsing had had little effect until the winter of 1957 when there was a reduction in the density of protecting fireweed. For the sowings made in April '56 and October '56 the effects of browsing, on the plots on burnt or unburnt slash, were insignificant in December '57.

In order to compare the development of seedlings on fenced and unfenced plots at Lords the heights of the four tallest seedlings on each plot were measured. The results of measurements made in April and December 1957 are shown in Table 4.10.

(1) PLOTS ON MINERAL SOIL.

The effect of browsing increased with the age of the plots, being greatest on the plots first sown and also increasing on the plots of any one sowing in the 8 months between measurements.

(a) Plots sown October '55. (Figs. 4.4 and 4.5)

Eighteen months after sowing the means of the four tallest seedlings on each of the two fenced plots were 42 ins. and 82 ins. compared with means of 7, 7.5, 17 and 18 ins. on the four unfenced plots. Eight months later the means on the fenced plots had increased by 31% and 26% to 55 and 103 ins. respectively compared with decreases in means on three of the four unfenced plots and an unaltered mean on the remaining one. As the scrub species were browsed in an equally drastic way, the visual effects in the field were even more striking than the measurements. (Figs. 4.6 and 4.7)

TABLE 4.10

EFFECT OF BROWSING

Heights (ins) of *E. regnans* seedlings on plots at Lords, Florentine Valley.
Plots 16 x 16 ft.
Means of 4 tallest seedlings; 2 plots for each treatment for each sowing on each seed-bed.

SOWING	MEASURED	TREATMENT					
		Fenced & Sprayed		Sprayed		Untreated	
<u>MINERAL SOIL</u>							
Oct. '55	Apr. '57	42	82	7.5	18	7	17
	Dec. '57	55	103	5.5	7	7	3
Apr. '56	Apr. '57	11	19	15	4	7	8
	Dec. '57	26	38	11	5.5	5	1
Oct. '56	Apr. '57	5.5	6	2.5	5	1.5	4
	Dec. '57	15	19	5.5	5.5	7	4
<u>BURNT SLASH</u>							
Oct. '55	Apr. '57	15	25	16	22	3	8.5
	Dec. '57	26	37	8	25	ø9	14
Apr. '56	Apr. '57	5	1	12	2.5	<1	<1
	Dec. '57	11	3	9	6	ø3	<1
Oct. '56	Apr. '57	1	1	1	2	1	<1
	Dec. '57	3.5	6.5	3	4	2.5	1
<u>UNBURNED SLASH</u>							
Oct. '55	Apr. '57	8.5	16	9	15	16	ø11
	Dec. '57	ø19	32	11	2	4	ø4
Apr. '56	Apr. '57	5	4.5	2	1	ø<1	-
	Dec. '57	13	10.5	ø4.5	ø1	-	-
Oct. '56	Apr. '57	<1	4	2	1	<1	1
	Dec. '57	<1	11	3	3	ø<1	<1

ø less than 4 plants on plot.

FIG. 4.4

(a) UNFENCED PLOT ON MINERAL SOIL
at Lords. Photographed on 19.10.55,
the day it was sown with E. regnans.
Logging, summer 1953/54.

(b) Same plot, photographed 12.7.56,
but from opposite direction. The
wire pegs are to the right of and
c.2 ins. from seedlings of E. regnans.
Light-coloured plants are Erechthites
prenanthoides.



FIG. 4.5

(a) Same plot as in Fig. 4.4 (unfenced, mineral soil, sown with E.regnans 19.10.55) photographed 25.3.58. Plants with leaves in rosettes are Carduus vulgaris. Fern is Hypolepis rugulosa. Erechthites prenan-thoides to right of peg.

(b) Seedling of E.regnans on same plot (sown 19.10.55; photographed 25.3.58). Seedling has been browsed at least twice. Card is $4\frac{1}{2}$ ins. square.

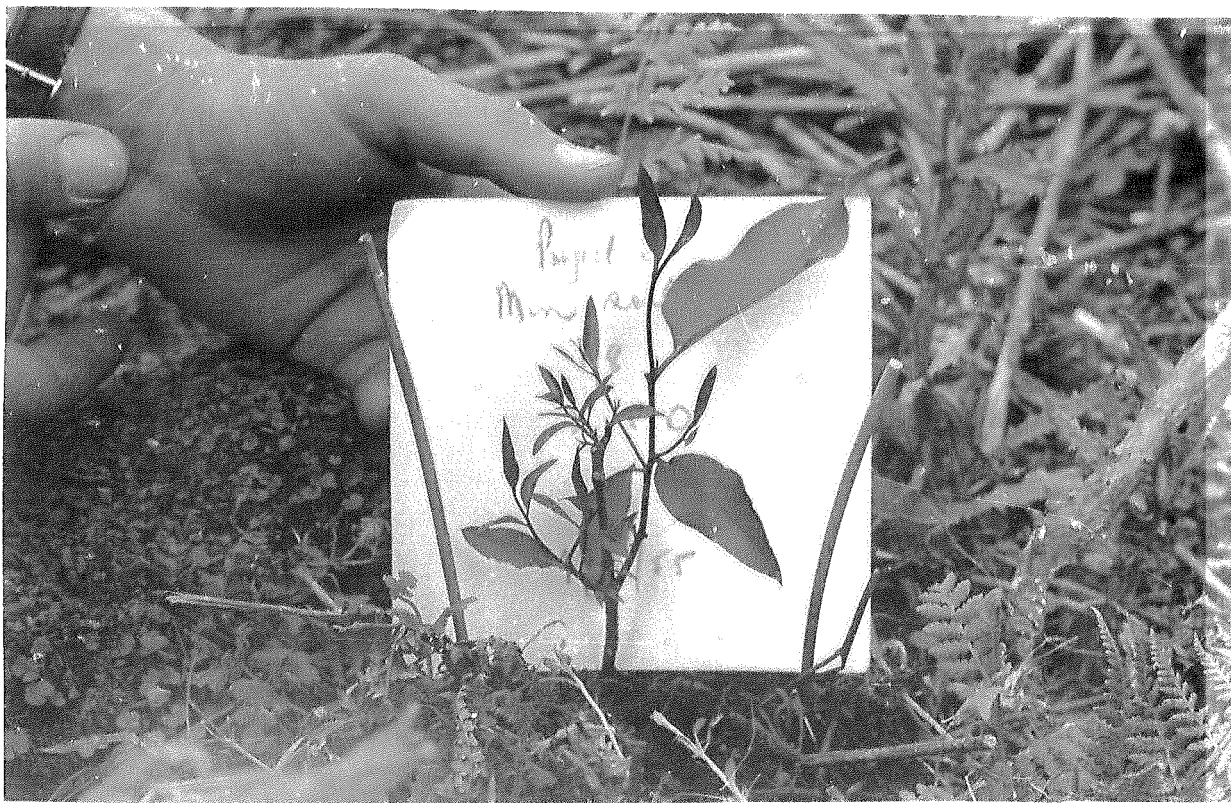
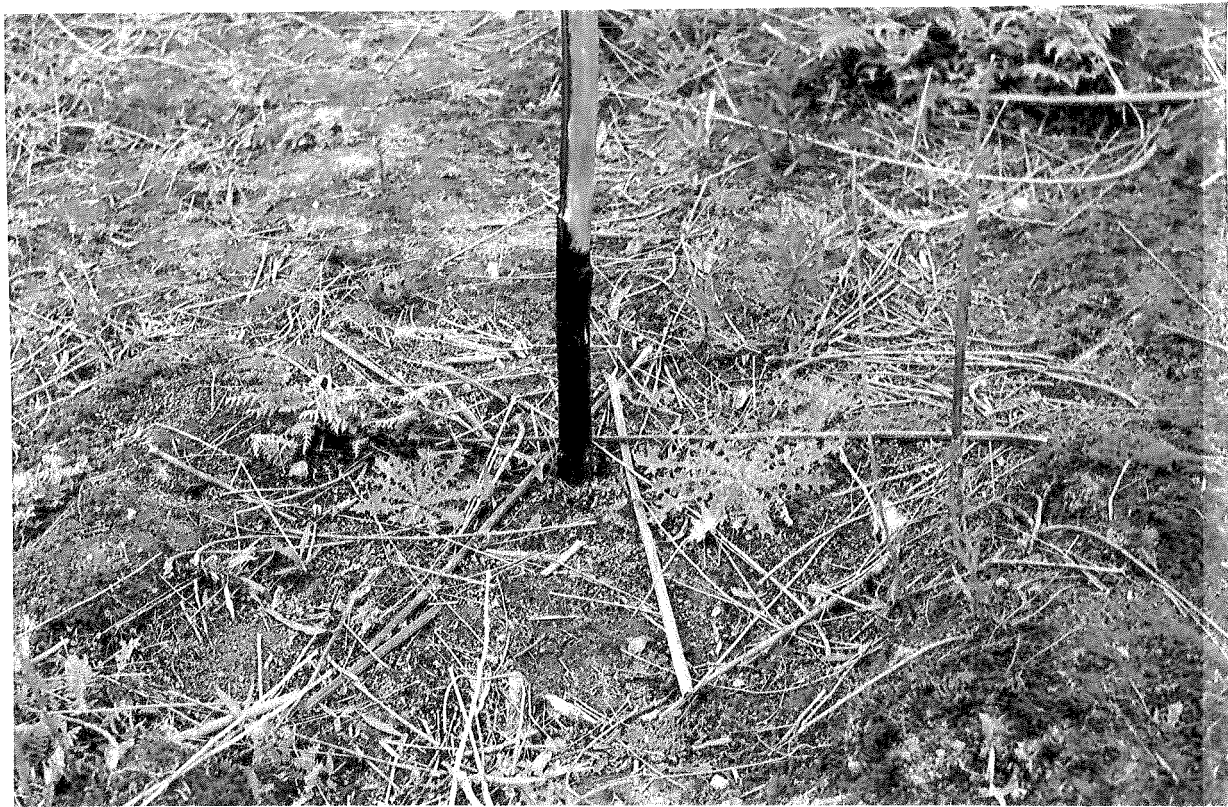


FIG. 4.6

(a) FENCED PLOT ON MINERAL SOIL
at Lords. Sown with E.regnans
on 19.10.55. Photographed 12.7.56.
Tallest eucalypt then c.30 ins.
Other plants are Erechthites
prenanthoides.

(b) Same plot photographed on
25.3.58. Mean of 4 tallest
E.regnans then c.110 ins. Acacia
dealbata are taller than eucalypts.
Effects of browsing seen on plot in
the foreground which was sown with
E.regnans in April 1956. Tall
plant of E.regnans came from natural
seeding. Area logged summer 1953/54.





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Fig. 4.7. Plot on mineral soil at Lords. Logged summer 1953/54. Fenced Oct. '56. Photograph March '58. Not sown with Eucalyptus. Inside fence principally Acacia dealbata and Pomaderris apetala (centre foreground). Outside fence dead flower stalks of Erechthites prenanthoides. Coppice of Atherosperma moschata.

From observations on older coupes it is clear that even where plants have been fully exposed to animals, browsing does not kill all the eucalypt seedlings. Also it cannot completely stop the growth of surviving seedlings. After three or four years the seedlings have grown to a size which prevents further browsing of the leading shoot. This stage had not yet been reached on the unfenced plots at Lords.

(b) Plots sown April '56.

Although browsing was first evident in December '56 - January '57, the effect on the height of the tallest seedlings was not very great in April '57. But by the following December the mean heights of the tallest seedlings had increased by 136% and 100% to 26 and 38 ins. respectively on the fenced plots compared with reductions on three of the four unfenced plots and an increase from 4 to 5.5 ins. on the other.

(c) Plots sown October '56.

Browsing had not been observed by April '57, when the means of the tallest seedlings ranged from 1.5 - 6 ins., but commenced in about October '57. By December the mean heights were 15 and 19 ins. for fenced plots and 4, 5.5, 5.5 and 7 ins. for unfenced plots.

(d) All sowings on Mineral Soil.

In December '57 the mean heights of the four tallest seedlings on fenced plots sown in October '55, April '56 and October '56 were 79, 32 and 17 ins. respectively but on unfenced plots there was little difference between the various sowings, the heights being about 6 ins.

If at the end of 1957 unfenced plots had been given protection from the animals, it would have been expected that the best immediate height growth would have

occurred on the oldest plots (sown October '55). When the eucalypt seedling has developed a more extensive root-system (and the chewed-off woody seedling perhaps becomes less palatable) it can recover quite rapidly from browsing and suddenly is beyond the stage at which further significant attacks can be made.

(11) PLOTS ON BURNED SLASH

Plots sown October '55. (Figs. 4.8 and 4.9)

Eighteen months after sowing there had not been any discernable browsing of eucalypts on these plots and the grouped means for seedling heights - 20 ins. for fenced plots and 12.5 ins. for unfenced plots - are not significantly different. It has already been seen that up to this stage survival rates for seedlings were similar on all plots.

The December '57 measurements show the effect of the browsing which occurred during the previous winter. The grouped mean on the fenced plots rose to 31.5 ins. (from 20 ins) and on the unfenced plots to 14 ins. (from 12.5 ins.). On one unfenced plot the mean of the four tallest seedlings dropped from 16 to 8 ins.

(111) PLOTS ON UNBURNED SLASH

Plots sown October '55. (Fig. 4.10)

Up to 18 months after sowing fencing had not given any advantage in height growth to the eucalypt seedlings. Eight months later (in December '57) there was a clear advantage for the fenced plots where the grand mean for the four tallest seedlings on each plot had risen from 12 to 25.5 ins. compared with a decrease for the unfenced plots from 13 to 5 ins.

FIG. 4.8

(a) PLOT ON BURNED SLASH at Lords.

Photographed on 19.10.55, the day
it was sown with E.regnans.

Urtica incisa on left and Erechtites
prenanthoides at centre and in R. H.
corners. Trunk in foreground is
Dicksonia antarctica; light-coloured
log on right is Atherosperma moschata.

(b) Same plot photographed 25.3.58.

E.regnans seedlings to c.36 ins.high.
Acacia dealbata on left. Upright
ferns on R.H. side are Polystichum
proliferum; remainder mainly
Hypolepis rugulosa.

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Fig. 4.9 Plot on burnt slash at Lords. Burnt Sept. '54. Fenced and sown with *Eucalyptus regnans* Oct. '55. Photograph March '58. Netting on left is 42ins. high.

FIG. 4.10

(a) FENCED PLOT ON UNBURNT SLASH
at Lords. Photographed on 19.10.55,
the day it was sown with E. regnans.
Stump and logs of regnans. Fern
near centre peg is Polystichum
proliferum. Some Erechthites
prenanthoides, Hypolepis rugulosa
and Histiopteris incisa.

(b) Same plot photographed 25.3.58.
Surviving E. regnans are up to 30 ins.
high but are hidden by the tall
Acacia dealbata on the right.
Polystichum proliferum near centre
pegs. Other ferns are Hypolepis
rugulosa and Histiopteris incisa.
Some dead flower stalks of
Erechthites prenanthoides.

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GENERAL DISCUSSION.

Under the conditions experienced in the Florentine Valley the best rates of germinations of regnans were obtained on bare seed-beds and if early survival and development were to be good the site had to remain bare for six to nine months after sowing. By this time seedlings had reached a height at which they could be browsed and as wallabies have a decided preference for moving about on cleared areas and along cleared tracks the seedlings on the bare areas suffered severely from browsing. Many seedlings recovered by developing shoots from buds in the leaf axils but were re-browsed; so that on the plots at Lords on mineral soil in December '57, maximum seedling heights were the same on plots sown in October '55, April '56 and October '56.

In the meantime, regnans seedlings on the slash plots had suffered heavy mortality because of the presence of weed-species but the surviving seedlings were protected from the animals by the very same weeds. It was not until the winter of '57 that a thinning of the weed species enabled browsing to occur but the effects were comparatively less pronounced than on the mineral-soil plots and it was not apparent that browsing had occurred a second time.

On the oldest, unfenced plots at Lords (sown October '55) prevention of browsing in December '57 would probably have resulted in much the same height growth of seedlings on all seed-beds but it is likely that browsing will continue for a longer period along the main logging tracks.

Recovery from browsing and growth to a point beyond further danger of attack can be very rapid. An area which had carried a mixed stand of regnans and gigantea was logged in 1951 and partly burnt in March 1953. At the end of April 1955 the regeneration was assessed by means of randomly-located, millacre quadrats. Regeneration was very good on areas of burnt slash (15 out of 22 quadrats stocked) but very poor on areas of unburnt slash (1 out of 28 quadrats stocked). The seedlings on the burnt quadrats had been severely browsed and early recovery did not appear likely. However by the winter of 1956 some seedlings were appearing above the fireweed and by the end of 1957 the burnt area and the logging tracks through it, were carrying eucalypt seedlings up to 15' high. (Fig. 5.3)

Browsing had checked seedling growth to the extent that after three years the area would have appeared poorly regenerated unless a close inspection were made.

PART FIVE

THE UTILIZATION
OF THE FORESTS
AND
SOME ASPECTS OF THE
REGENERATION
OF THE EUCALYPTS

PART FIVE: THE UTILIZATION OF THE FORESTS AND SOME ASPECTS OF THE REGENERATION OF THE EUCALYPTS.

I. GENERAL OBJECTIVES.

1. STOCKING OF EUCALYPTS

In terms of the annual rate of production of wood - whether total volume or volume suitable for pulping or sawmilling - the eucalypts are far superior to the species of the understory. On good sites, regnans, obliqua and probably gigantea will produce 2,000 super ft. (Hoppus) per acre per year for the first 80 years (Forestry Commission plots) whereas the combined production of Nothofagus and Atherosperma would not often exceed one-quarter of this amount.

As a general-purpose sawmilling timber, the eucalypt is superior to the rainforest species and in addition is the raw material for groundwood pulp, the basic ingredient for the pulp used to produce newsprint in Australia's only newsprint mill (Boyer, Tasmania, 1958). Therefore any effort made towards the regeneration of cut-over or poorly-stocked areas should aim to produce eucalypt wood to the full capacity of the site. The objective should not be, in fact cannot be, the exclusion of rainforest or scrub species, as in areas of high rainfall, an understory will inevitably develop, even in overcrowded stands of eucalypts.

2. REGENERATION PERIOD

On the high-quality sites it is fairly certain that the rotation will be less than 100 years for the

production of wood for general purposes and probably about 50 years for pulpwood. If 50 years is the most economical rotation for the production of the class of material required, delays of several years in getting regeneration established must add considerably to the cost of producing the material.

On silvicultural grounds delays in the establishment of eucalypt regeneration will be serious in areas of high rainfall because the possibility of getting seedlings established will diminish rapidly with the passing of time. On cut-over areas of mixed forest the seedlings of species other than Eucalyptus may at first be few in number, slow in growth and browsed. Then after about three years species such as Acacia dealbata, Pomaderris apetala and Olearia argophylla suddenly grow beyond the height at which they may still be browsed and with ferns becoming dense there is a rapid reduction in the area and quality of seed-bed which is suitable for eucalypts.

II. THE PROBLEM OF THE UNDERSTORY.

1. ECOLOGICAL EVIDENCE

Eucalypts do not regenerate if an understory of rainforest species is present and the continued existence of the eucalypts has depended on fires which have occurred at intervals shorter than the life-span of the eucalypts. Eucalypt seed can germinate beneath a full canopy of rainforest species but on the sown plots established in these studies survival was not usually beyond the cotyledon stage and never beyond the first-leaf stage. (Part Three - Table 3.14 & Fig. 3.10).

NO MATTER HOW MUCH SEED IS APPLIED, AN INTACT UNDERSTORY CONSTITUTES AN ABSOLUTE BARRIER TO EUCALYPT REGENERATION.

In the virgin forest the gaps caused by the falling of individual eucalypts (usually decadent), or smaller groups of the trees of the understory, are not suitable for eucalypt regeneration either because the gaps are not large enough, the seed-bed is not suitable or there is insufficient seed. Over the many hundreds of acres of virgin mixed forest which have been traversed by foresters in the Florentine and adjoining valleys, only one instance has been seen of eucalypts having regenerated in the absence of fire or of man's activities in opening up the forest. The regeneration consisted of one sapling. (Part One - V. The role of fire in forest succession).

2. THE EFFECT OF THE UNDERSTORY WHICH REMAINS STANDING AFTER THE EUCALYPTS HAVE BEEN LOGGED.

In the Florentine, the eucalypts are logged by two methods:-

- (1) High-lead which involves snigging the log by

a wire rope which passes over a block fixed high on a topped tree (Fig. 5.4). Except around the perimeter of the coupe, few trees remain standing in areas logged by this method (Fig. 2.2).

(11) Tractor logging. The logs are snigged by crawler-type bull-dozers along numerous but defined tracks which are cleared by the bull-dozer. Much of the understory remains standing between the tracks, the proportion increasing towards the boundaries of the coupe (Fig. 5.1).

Even small groups of understory trees will prevent the establishment of eucalypts and unless the coupes which are logged by tractor are burnt or the understory felled, a fairly large proportion of the area will not regenerate with eucalypts. In the gap experiment (No.3) the growth of tubed eucalypts was much reduced in the smallest gaps (light intensity approximately $1/16$ of that in the open). These gaps were most irregular in shape, and the nature of the surrounding vegetation was very variable, but in general terms they could be described as being less than a tenth of an acre and with trees up to 100 ft. high around 75% of their perimeter. Direct sunlight would be received only for very short periods each day. Seventeen months after planting the eucalypts had a mean height of 24.5 ins. in the very small gaps compared with 39-40 ins. for all other gaps, i.e. growth in length had been 21 ins. in the smallest gaps and 35 ins. in the larger gaps. Of the 64 seedlings planted in each class of gap, twenty-one had died in the very small gaps and an average of thirteen in the other gaps.



Fig. 5.1. Rainforest understory left standing after logging the eucalypts from mixed forest. Darker stems are Nothofagus cunninghamii, lighter ones Atherosperma moschata. Slash has been burnt and most of remnant understory dies. Lawrence's Ck. Road, Florentine Valley.

3. REMOVAL BY FIRE OF THE REMNANT OF THE UNDERSTORY.

The removal of the standing remnants of the understory from cut-over areas of mixed forest is a major problem. Fire can be used and has been used successfully (Fig. 5.1), but there are many provisos. The amount of logging slash must be sufficient to provide a fire hot enough to kill the trees of the understory under conditions which give a reasonable chance to keep the fire within bounds. Unless large sums of money are to be spent on preparatory work, control must depend largely on the difference in inflammability between the slash on the cut-over area and the fuel in the adjoining forest. Because rotten logs and decadent trees (particularly Nothofagus) may smoulder for many weeks after a fire - sometimes months - it has become the practice to burn logged areas of mixed forest in the autumn rather than the spring, so that undetected smouldering fires do not burn on into the summer. Autumn burning is usually delayed until the first good rains in March but once the season has broken the cut-over areas may not dry out again to the point where burning is possible. Much careful organization is required to burn an annual cut of 1000 acres which is dispersed in 20-40 acre coupes.

4. USE OF THE UNDERSTORY.

Removal of the understory by fire is thus risky and uncertain. It also involves the destruction of wood which in future may be usable as the commercial demand increases. However the problem has to be looked at in the light of demands for wood now, in 1958.

In Southern Tasmania at present the understory species provide material for wood-fashioning industries which turn out boards for furniture, interior trim and

flooring and articles such as clothes-pegs, bobbins and shoe-heels. For the first set of items most of the wood comes from Nothofagus but it has to compete with the lower-priced, more easily fashioned eucalypts, and the demand for the second set of items is limited. In the mixed-forests being logged primarily for eucalypts there are far more logs of the understory species than are needed to meet the demand. Even if the demand were increased there is only a low proportion of the trees of Nothofagus and Atherosperma suitable for saw-logs. Numbers of the logs are too small and many which are large enough are of poor form and partially decayed.

Data from the transect in mixed-forest in the Styx Valley (Part One IV. Forest Types) are indicative of the position - Table 5.1.

TABLE 5.1 Number of stems per acre of Nothofagus and Atherosperma greater than 6 ins. G.B.H. on transect in mixed forest in Styx Valley.
Total number and number suitable for saw-milling.

SPECIES:	NOTHOFAGUS		ATHEROSPERMA	
	GIRTH - FT:			
	0.5-2.0	>2.0	0.5-2.0	>2.0
Total number	36	24	280	94
No. of sawlog trees	-	12	-	16

Regnans were present at the rate of six per acre but only two were merchantable. Even if the data overstate the position it should be remembered that on many coupes the understory is not logged.

The small and inferior trees of the understory would yield suitable material for the manufacture of hard-board but at present the market in Australia is satisfied by existing plant capacity. The suitability of the material for pulpwood is being investigated by Australian Newsprint Mills and a pulp of good colour and strength has been obtained from Atherosperma by using a semi-chemical process (chips soaked in cold solution of caustic soda and the fibres then separated in screw-presses and refiners). On areas being logged by the Company for Atherosperma, trees down to 8 ins. D.B.H. are taken and after meeting the demand for saw-logs, the remainder are pulped. However, for many years to come the overall position will be that the understory in mixed forests in Southern Tasmania is not likely to be utilized sufficiently for full regeneration of eucalypts to occur.

The use of small trees of Atherosperma is a major step forward but at present could not be applied on all areas being logged. In the meantime measures which could be taken in partial solution of the problem, are:-

(i) as far as possible, logs of rainforest species should be obtained from mixed forest and not from pure rainforest or areas carrying only scattered eucalypts. The aim should be to use the understory species on as high a proportion as possible of the mixed forest logged for eucalypts.

(ii) fell all small understory trees (6-24 ins. G.H.B.) left standing after logging. Even if the coupe is not burnt the cost of felling the large, reject trees of the understory would probably not be commensurate with the improvement in conditions for the establishment of eucalypts. Data from transects indicate the number of

trees involved - Table 5.2.

TABLE 5.2. Number of stems per acre of Nothofagus and Atherosperma, greater than 6 ins. G.B.H. on transects in mixed forest.

LOCATION	NOTHOFAGUS		ATHEROSPERMA	
	6-24"	> 24"	6-24"	> 24"
Tyenna Valley	13	24	73	68
Styx Valley	36	24	280	94
Florentine Valley (Road 10)	32	42	177	60

(iii) burn the coupe. If all trees between 6 and 24 ins. G.B.H. were felled, there would be an increased chance of getting successful and safe burns.

III. ESTABLISHMENT OF EUCALYPTS ON AREAS CARRYING TEMPERATE RAINFOREST.

For reasons mentioned in the last section, in mixed forests the logging of large patches of temperate rainforest should be deferred until increased demand for the wood of the rainforest species makes it possible to log more intensively.

Should it be desired to establish eucalypts on areas of rainforest it can be accepted that this could be done successfully in cases where eucalypt logs can be identified on the ground. This has been demonstrated in the trials at Road 7A, Florentine Valley, in which regnans seed was sown on an area where huge eucalypt "downers" were present. In the absence of "downers" the height of the rainforest can be taken as an indication of the quality of the site. Pending trials, measurements on transects and general observations suggest that regnans could be established on any site carrying rainforest in which the height of the dominants exceeds 100 ft.

A full stocking of eucalypts will not be achieved unless the existing crop of rainforest is removed or killed.

IV. NATURAL REGENERATION OF MIXED FOREST

1. THE UNDERSTORY

The problem of the understory has been discussed and it is sufficient to repeat that no matter how much seed is applied, an intact understory is an absolute barrier to eucalypt regeneration.

2. THE SEED-BED

In sowing trials, bare mineral-soil generally proved superior as a seed-bed to burnt or unburnt slash and where compaction was virtually absent (as in the gap experiment, No.3) the rate of germination was very high. From observations of eucalypt seedlings on roadside cuttings and along logging tracks, it is apparent that even the extreme disturbance caused by a bulldozer creates a reasonably good seed-bed but should the soil be consolidated the seed-bed is extremely poor.

Around points where logs are marshalled and loaded, consolidation may extend over an area of several square chains, and continue along the tracks on which the logs are snigged. In both cases the clay sub-soils are churned into a structureless mass, the surface of which dries with a brick-like hardness.

However, Acacia, Carex and Gahnia soon appear and with slow improvement of the site a few eucalypts may become established from natural seeding. It would appear that no reasonable means exists of extracting 200 to 300 tons of logs per acre over clayey soils in a cool, wet climate without making the logging tracks and marshalling points unsuitable seed-beds for eucalypts.

Cunningham (1955-58) sought to increase the number of regnans seedlings by baring the mineral-soil before felling commenced (forest without dense understory). This would be a very costly operation in mixed forest where the only practical means of improving the seed-bed would appear to be by burning the logging slash. Much of the seed in the slash would be destroyed and sowing of seed might be necessary. Besides improving the seed-bed the fire would also destroy remnants of the understory.

In considering seed-beds where slash has been burnt it should be borne in mind that the condition of such seed-beds may be very different from those resulting from fire in virgin forest. The severe ground-fire caused by large piles of logging slash leaves behind a surface soil from which all organic matter has been burnt and one which dries out rapidly. The death-rate among very small seedlings is often high on such seed-beds. Again this disadvantage is outweighed by the advantage gained from burning the slash.

Germination of eucalypts may be satisfactory on organic matter (Ao horizon) but if the layer is more than an inch or two thick, there is a poor survival of seedlings.

Seedling establishment is poor on areas covered by slash (Part Three - Tables 3.17 and 3.18). Scorings of plots in slash indicated a low rate of germination but to some extent this was attributable to the fact that the slash was disturbed as little as possible while scoring was being done and a thorough search for seedlings at the cotyledon stage was not possible. However it is certain that very few seedlings survive. But slash is not uniformly dense and small clear spots occur on which the surface soil has been disturbed by up-rooting of trees, movement of tractors and logs etc. If adequate seed trees are present burning of the slash would be of advantage. Figs. 2.2, 3.2 and 4.10 show the heavy slash which may be present after

logging. The area shown in Fig. 5.4 was logged by high-lead.

3. SUPPLY OF SEED

Seed for the regeneration of the eucalypts could come from that shed prior to logging, from the heads of felled trees and trees knocked down in logging, or from trees left standing after logging.

(1) Seed shed prior to logging

In the virgin forest, eucalypt seed is unlikely to remain viable in or on the surface soil for more than a year and probably for no longer than six months. In the gap experiment (No.3) sowings were made on 11.10.56 and germinations had ceased within seven months in all but the largest gaps. Under the full canopy of the understory there were no germinations after five months from sowings made on 19.10.56. It is considered that of the seed which is shed in virgin mixed forests, some germinates (the germinants die), some rots and the rest is taken by insects.

Even if only a small proportion of the seed was stored for a few years in the surface soil, a reasonable amount of regeneration might be expected after logging on areas where only a small quantity of seed was present on standing trees or in the slash.

The amount of seed at Lords (Exper.1) was meagre and on the twenty-seven 16 x 16 ft. plots established in October '55, 18 months after logging, only 50 seedlings per acre were present from natural seeding. The twenty-seven plots established in April '56 had seedlings at a rate of 70 per acre and the October '56 plots, only 60 per acre.

(11) Seed on the heads of felled trees

If a large number of trees per acre are felled, seed from the capsules on the heads of the felled trees could be shed fairly generally over the area but in mixed forest, which is more than 250-300 years old, there are only a few trees per acre.

On many parts of high-lead areas the slash will be a barrier to a full stocking of eucalypt seedlings, which could only be achieved by burning the slash, followed by sowing or planting. Should the logging slash on such areas be burnt natural regeneration of eucalypts could be expected to be poor as few trees remain standing after logging and the seed on the heads would be destroyed.

In the mixed forest the heads of the eucalypts could not be scattered easily and no practical means can be envisaged by which more effective use can be made of the seed in the heads except by gathering the capsules, extracting the seed and sowing it.

Thus fellings make the seed position very much worse on areas where it is probably already limiting, that is where there are only a few trees per acre.

(iii) Seed on trees standing after logging

The complete regeneration of cut-over areas of mixed forest from natural seeding generally will depend on the seed carried by trees left standing after logging; including trees on adjoining un-cut stands. The exception is the case where young forest (up to 150 years, 30 trees per acre) is logged by high-lead and almost all the trees are felled or knocked down during logging.

If the trees were 250 ft. high and carried a good crop of seed, three trees per acre would be sufficient to seed the area by shedding seed in the eastern half of a

circle 300 ft. in radius around each tree.

Usually lack of regeneration under apparently suitable conditions is caused by lack of seed. On the plots at Lords (Exper.1) seeding at a rate of 2 lbs.per acre on unburnt slash, without control of harvesting insects, gave a minimum of 170 seedlings per acre on four plots (16 x 16 ft.) out of six, 14-24 months after sowing. Many of the seedlings may die but the results indicate that, if seed is applied at the rate of several pounds per acre, some seed should fall on the few favourable spots which are present, even in areas of heavy slash.

The rate of the fall of sound seed on the Road 11 seed-trapping area, together with the plants which would be obtained at a tree % of 0.5, is shown in Table 5.3.

TABLE 5.3 The rate of fall of sound E.regnans seed - per acre per year - according to distance to the south-east of seed-trees, and estimate of plants therefrom.

Road 11, Florentine Valley.

Distance from trees - feet:	50	100	150	200	250	300	350	400
Viable seed/acre/ year - thousands:	204	120	66	30	24	18	12	6
Plants per acre at tree % of 0.5:	1020	600	330	150	120	90	60	30

Even if continuing crops of seed were available, rates of fall of the order 1/5 lb. per acre per year, at 200 ft. from the seed tree, mean that before sufficient seed falls, weeds may have developed to the point where the establishment of eucalypt seedlings is prevented.

The quick release by fire of seed from standing trees is of advantage.

4. LOGGING METHODS AND REGENERATION FROM NATURAL SEEDING.

In considering possible amendments to present logging practices as means of increasing the amount of natural eucalypt regeneration it is necessary to bear in mind certain factors which set the basic pattern of the logging. The eucalypt logs are very large and heavy. Large tractors and other heavy-duty equipment are required to handle them and it is expensive to build logging roads, assemble plant and equipment on a coupe, set a loading rig and in the case of high-lead logging, a hauling rig as well. Log costs will be very high unless a large quantity is handled by each rig. However, beyond fairly precise distances of haul it is more economical to build more road and to rig another spot for the marshalling and loading of logs. When all these factors are considered coupes are found to vary, in practice, from about 20 up to 40 acres, the size depending on topography, the volume of wood per acre and whether logging is by high-lead or tractor. Coupes logged by tractor tend to be the larger.

Coupes are usually too large to be restocked, except in part, by seed blown in from adjoining uncut stands. If trees were especially reserved as seed-trees within the coupe, loading facilities would need to be left in place at each landing until regeneration was established (say up to two years), or the loading facilities re-established. Regeneration of large portions of each coupe will depend on seed shed by reject eucalypts left standing after logging. The reject trees are not always inferior phenotypes, especially in the older stands, but may fail to

meet log specifications because of faults which have developed from mechanical injury in the past. However the possible genetic deterioration of the forests by leaving the poorest trees as parents should not be overlooked.

There is a possible sequence of logging which would aim to simulate the conditions which follow wild fire in virgin forest i.e. removal of the understory, preparation of a suitable seed-bed and the release of the seed from the eucalypts - most of which will have remained standing. The suggested sequence of logging is:-

- (i) fell and log the understory and cut down the small trees (below 6-8 ins. diameter)
- (ii) burn the understory-slash
- (iii) fell and log the eucalypts at any time after their seed has been shed.

This could not be done on all areas and would need large-scale trials to study such things as the extent of the breakage of eucalypt logs in falling on the stumps of the felled understory trees and the amount of damage to eucalypt seedlings from the final logging. Limited experience suggests that neither of these factors is likely to prevent the adoption of the suggested sequence of logging. A somewhat similar system is being used to regenerate karri forest (E. diversicolor) in Western Australia. On a small area on which such a logging sequence was in part achieved (the eucalypts, an isolated patch, were not felled) the regeneration of eucalypts was very satisfactory, two years after the slash had been burnt. The area covered 7.7 acres and carried regnans at the rate of 3.4 per acre (5.5 per acre on 2.9 acs. and 2.1 per acre on 4.8 acs.). The eucalypt seedlings were counted on five strips, each



Fig. 5.2. Mixed forest in which understory species were logged, the slash partly burnt and the remnant of the understory felled. Eucalyptus regnans not logged. Good eucalypt regeneration was obtained. Road 7A, Florentine Valley.

10 links wide, the score being recorded for each 10 links of strip - Table 5.4.

TABLE 5.4 Number of seedlings of *E. regnans* on an area of mixed-forest in which the under-story was logged, useless trees felled and slash burnt. Eucalypts left standing.
Road 7A, Florentine Valley. Fig. 5.2.

STRIP NO.	NO. OF MILLACRES			NO. OF SEEDLINGS		
	STOCKED	UN-STOCKED	% STOCKED	ON STRIP	PER ACRE	
					ALL MILLACRES	STOCKED MILLACRES
1	25	32	44	82	1,440	3,280
2	36	40	47	127	1,670	3,530
3	20	40	43	89	1,480	4,450
4	29	41	41	92	1,310	3,180
5	12	41	23	42	790	3,500
TOTAL /MEAN	122	194	39	432	1,370	3,540

Cunningham (1955-58) considered regeneration to be satisfactory if 300 of each 1,000 millacres carried one or more seedlings and estimated that this would give 1,000 seedlings per acre. Jacobs (1955) was of the opinion that 5,000 seedlings per acre were



Fig. 5. 3. Mixed forest in which eucalypts logged and slash burnt (March'53). The fire killed the remnant of the understory and good regeneration resulted from seed from eucalypts, (regnans and gigantea), left standing; near Road 9, Florentine Valley.



Fig. 5. 4. HIGH-LEAD LOGGING in Eucalyptus regnans forest with an understory of Nothofagus cunninghamii and Atherosperma moschata. Spar tree, to which logs are hauled, is in middle background. Florentine Valley.

required before full stocking was achieved from natural or broadcast seeding. On the Road 7A area an increased rate of seeding would probably have increased the percentage of stocked millacres but because of poor seed-beds on some millacres an increase beyond a certain point in the rate of seeding would give poor returns in terms of additional stocked millacres. More seed cannot make a poor seed-bed into a good one. This was shown to be the case with E.grandis on the North coast of N.S.W. (Floyd 1957).

Kitchener (1958) has investigated recent developments in logging equipment in the U.S.A. A type of mobile hauler-loader is being considered for use in the Florentine. From a stationary position this machine can pull in logs over a distance of 300 ft. and could load 75% of the eucalypt logs without having to be guyed. When guys are required they can be rigged in hours instead of days as is the case with topped trees. Such machines would probably give greater flexibility to logging, facilitate pre-logging of the understory, and eucalypt seed trees could be retained and logged after regeneration was established.

V. ARTIFICIAL REGENERATION

1. SOWING

Eucalypt seed can be collected from current coupes at a reasonable cost (£2-£3 per pound). However, whether the seed is broadcast or spot-sown the problem is to get a sufficient proportion of suitable seed-bed to ensure a full stocking of eucalypt seedlings. For broadcast sowings the same improvement of the seed-bed could be made as for natural seeding. Essentially this means the disposal of logging slash by fire. The advantage inherent in broadcast sowing is that some seed would probably be applied to all areas on which the seed-bed is suitable.

With spot-sowing, it is possible to do a small amount of preparation to the spot to be seeded e.g. a heavy hoe can be used to remove layers of litter or light logging slash or to give rough cultivation. No practical means can be envisaged by which successful sowing or planting spots can be developed for eucalypts on the areas of consolidated soil along logging tracks or around log-marshalling points. The only real loss of stocking is around the marshalling points as plenty of spots suitable for sowings can be found on the edges of the tracks.

By giving the seed some protection from seed-harvesting insects (see below) and by restricting sowings to areas of suitable seed-bed, seeding rates of 2 lbs. per acre should be adequate for broadcast sowings. Higher rates of seeding with indiscriminate sowing would tend to increase the density of seedlings on the suitable seed-beds rather than increase the proportion of the whole area on which seedlings become established.

2. PROTECTION OF SEED FROM INSECTS

Before it is sown, eucalypt seed should be dusted with D.D.T. A two-fold increase in the number of seedlings can be expected (Part Three - Fig.3.8). The application of sprays, such as dieldrin, would give good results but the cost of applying something like 100 gallons of spray material per acre would be very high on cut-over areas of forest such as occurs in the Florentine. Spraying would increase the number of seedlings arising from natural seeding but it would be cheaper to increase stocking by collecting seed, dusting it with D.D.T. and broadcasting it.

3. PLANTING

It is highly probable that planting will result in a level of success of establishment superior to that obtained from sowings. Eucalypt seedlings grown in tubes go to the field in a well-established condition and can be planted with little disturbance to their root systems. Being well-established they can withstand temporarily unfavourable conditions and can quickly get above competing weed-species. The persistence of established eucalypt seedlings was demonstrated in the case of plantings made beneath the full canopy of an understory of rainforest species (light intensity $1/50$ - $1/100$ of open). The plants (regnans) had been grown in tubes and were poor plants surplus for other requirements. When planted in October '56 their heights ranged from 1-3 ins. In April '58, seven of the eight plants were still alive and their mean increment in height had been 8 ins. Under the same conditions on small broadcast plots sown in October '56, no seedlings survived beyond the first-leaf stage, all having died by May '57 (Part Three - Fig.3.10). Nursery stock of eucalypts will not survive if they are planted

under light intensities less than $1/50$ of that in the open. Regnans seedlings may take four years to make their way up through bracken fern (Ashton 1957) but need to become established while the bracken is open.

The initial advantage of tubed seedlings was also demonstrated in the gap experiment. Sowings and plantings were made in October and November '56 respectively. The tubed seedlings were not particularly good (2-12 ins.) but by December '57 their mean heights were 13, 20, 18 and 19 ins. in going from very small to large gaps. The seedlings from the broadcast seed had mean heights of 4, 6, 4 and 5 ins. over the same range of gaps. By the beginning of April '58 the mean heights of the tubed seedlings were 24, 40, 39 and 39 ins., a quarter of the plants in the large and medium sized gaps being 60 ins. or taller.

Planting gives poor results in soils consolidated by logging operations. In the same way as with sowing, planting spots should be sought along the edges of such areas.

It is expensive to raise eucalypts in the nursery and there is a need to investigate plantings at wide spacings. In the high quality forests growing in areas of high rainfall, species such as Acacia dealbata and Pomaderris apetala grow so quickly that they may serve to promote good form and the early shed of the lower branches of the eucalypts. These desirable features are usually associated with a full or over-stocking of eucalypts.

4. EFFECT OF BROWSING

Browsing may cause a big reduction in the number of seedlings and hinder the development of the seedlings (Part Four - Tables 4.7 and 4.10). Where the movement of wallabies is not impeded by weed-species, or slash, the effects are most marked and are particularly severe along logging tracks which become the main avenues for animal movement. Damage to seedlings by brush possum in stands has been observed but its extent and importance is not known.

The exclusion of browsing mammals would result in an increase in the number of established eucalypt seedlings obtained from natural seeding and the attainment by the seedling of a greater height in its first few years (Part Four - Tables 4.7 and 4.10). If time and money are expended in sowing or planting, some effort should be made to reduce the number of animals. Investigations will need to be made into means of control and a study made of the animals' habits in moving and feeding. Any improvements of the site which involves the clearing of lanes is likely to give poor results because the movement of the animals will be channelled into the lanes and seedlings there will be subjected to severe and repeated browsing. Widespread clearances are better, e.g. those resulting from the burning of slash. It is not feasible to achieve widespread improvement of the seed-bed by mechanical means in ^{the} mixed forests of the Florentine.

A reduction of animal-numbers could be achieved by old-established methods such as snaring and it would be worthwhile to assess the effect of such measures. In the long run, control measures are likely to be more effective if based on a sound knowledge of the ecology of the animals concerned.

5. THE REGENERATION PERIOD

For one or two years after logging there may be little evidence of the development of so called weed-species. Established clumps of ferns may become dense and fireweeds appear but species such as Acacia dealbata, Pomaderris apetala and Olearia argophylla become established slowly. Over this period eucalypts may germinate and become established. Two to three years after logging the development of weed-species gains momentum and then the eucalypts can only become established on a rapidly diminishing percentage of the coupe. A reduction in browsing appears to be coincident with the increase in the growth of weed-species but it is not certain which is the cause and which the effect. While the reduction in browsing would enable eucalypt seedlings to grow unchecked, the competition from the weed-species would be severe to small plants.

If eucalypt regeneration is not obtained naturally after logging or burning, any effort in artificial establishment should be made as soon as possible. The period during which eucalypts may be established can be lengthened by the use of nursery stock but even planting may fail, except on restricted areas, if the time since logging is longer than about three years.

REFERENCES

- ALLEN, G.S. 1954. Slash burning - silvicultural aspects of the problem. Brit. Columbia Lumberman 38.
- ASHTON, D.H. 1955. Some problems concerning the regeneration of mountain ash in Victoria. Paper to A.N.Z.A.A.S. meeting, Melbourne.
- 1956. Studies on the autecology of Eucalyptus regnans F. & M. Ph. D. Thesis Uni. of Melbourne.
- BANKS, M.R. 1957. Personal communication.
- BARRETT, L.I. 1943. Hardwood invasion in pine forests of Piedmont Plateau. Journ. Ag. Res. 67.
- BATEMAN, A.J. 1947. Contamination in seed crops III. Relation with isolation distance. Heredity 1: 303-336.
- BAUR, G.N. 1957. Nature and distribution of rainforests in New South Wales. Aust. J. of Bot. 5: 190-233.
- BEADLE, N.C.W. & COSTIN, A.B. 1952. Ecological classification and nomenclature. Proc. Linn. Soc. NSW. 77: 61-82.
- BLAKELY, W.F. 1934. A key to the eucalypts. The Workers Trustees, Sydney.
- 1955. 2nd edition. C'wlth. Govt. Printer, Canberra.
- BURGES, A. & JOHNSTON, R.D. 1953. The structure of a New South Wales sub-tropical rain-forest. J. of Ecol. 41: 72-83.
- CARRON, L.T. & HALL, N. 1954. National forest inventory: Beech Forest (Victoria) military area - western half. Aust. Forestry 18: 128-140.
- CLIFFORD, H.T. 1953. A note on the germination of Eucalyptus seed. Aust. Forestry 17: 17-20.
- CROMER, D.A.N. & PRYOR, L.D. 1942. A contribution to rainforest ecology. Proc. Linn. Soc. NSW. 67: 249-268.

- CUNNINGHAM, T.M. 1955-58. Personal communications.
 — 1957. Seed production and seed fall of E.regnans (F.Muell.). Aust. Forestry 21: 30-39.
- CURTIS, W.M. 1956. The students flora of Tasmania. Govt. Printer, Hobart.
 — & SOMERVILLE, J. 1949. Vegetation; in Handbook for Tasmania. A.N.Z.A.A.S.
- DAVIES, J.L. 1958. The Cryoplanation of Mount Wellington. Pap. Proc.Roy.Soc.Tas. 92: 151-154.
- DAVIS, C. 1940. Preliminary survey of the vegetation near New Harbour, south-west Tasmania. Pap.Proc.Roy.Soc.Tas. 1-9.
- EGGELING, W.J. 1947. The ecology of the Budongo rainforest, Uganda. J.of Ecology 34: 1, 20-87.
- FERGUSSON, K.V.M. & CHINNER, J.H. 1955. Forests and forestry, in Introducing Victoria; A.N.Z.A.A.S. Melbourne.
- FIELDING, J.M. 1956. Notes on the flowering and seeding of Eucalyptus delegatensis and E.fastigata in the Australian Capital Territory. Aust.Forestry 20: 1, 40-43.
- FLOYD, A.G. 1957. Personal communication.
- FORESTRY & TIMBER BUREAU CANBERRA. 1953. Supplement to "A Key to the Eucalypts" (Blakely, 1934) National Mapping Office, Canberra.
- FORESTRY COMMISSION, TASMANIA. Departmental records.
- FRAZER, L. & VICKERY, J.W. 1938. The ecology of the upper Williams River and Barrington Tops District. Pt.II. The rainforest formations. Proc.Linn.Soc.NSW. 53: 3-4, 139-184.
- GALBRAITH, A.V. 1937. Mountain Ash (Euc.regnans F.von Mueller). A general treatise on its silviculture, management and utilization. Govt. Printer, Melbourne.

- GEIGER, R. 1950. The climate near the ground. 2nd edition. Harvard Uni. Press.
- GIBBS, L.S. 1921. Notes on the phytogeography and flora of the mountain summit plateaux of Tasmania. *J. of Ecol.* 8: 1, 1-17, 2, 89-117.
- GILBERT, J.M. 1949. Fire Control in Tasmania. *Aust. Forestry* 13, V.1, 34-39.
- 1949. Forestry; in Handbook for Tasmania. A.N.Z.A.A.S.
- 1955-57. Reports to Forestry & Timber Bureau, Canberra.
- GROSE, R.J. 1957 a. Notes on dormancy and the effect of stratification on the germination of some eucalypt seeds. *Vict. For. Comm. Bull.* No. 3.
- 1957 b. A study of some factors associated with the natural regeneration of alpine ash, *Eucalyptus delegatensis* R.T. Baker syn. *E. gigantea* Hook.f. *Vict. For. Comm. Bull.* No. 4.
- 1957 c. Personal communication.
- GUILER, E.R. 1957. The present status of some Tasmanian mammals in relation to the fur industry of Tasmania. *Pap. Proc. Roy. Soc. Tas.* 91: 117-128.
- HANSEN, H.P. 1950. Pollen analysis of three bogs on Vancouver Island, Canada. *J. of Ecology* 38: 2, 270-76.
- HERBERT, D.A. 1936. An advancing beech forest. *Q'land Naturalist*. 10: 1, 37-39.
- 1938. Upland savannahs of the Bunya Mountains, South Queensland. *Proc. Roy. Soc. Qld.* 49: 145-149.
- HOLLOWAY, J.T. 1954. Forests & climate in the South Island of New Zealand. *Trans. Roy. Soc. N. Z.* 82: 329-410.
- IREDALE, T. & TROUGHTON, E. LeG. 1934. A check-list of the mammals recorded from Australia. *Mem. Aust. Mus. Sydney* No. 6.
- JACKSON, J.K. 1956. The vegetation of the Imatong Mountains. *J. of Ecology* 44: 2, 341-374.

- JACKSON, W.D. 1956. Personal communication.
 — 1958. The vegetation of the lower
 Pieman River region. Pap.Proc.Roy.Soc.
 Tas. (in print).
- JACOBS, M.R. 1936. The primary and secondary leaf
 bearing systems of the eucalypts. C'wlth.
 F.& T. Bureau, Canberra Bull. No.18.
 — 1955. Growth habits of the eucalypts.
 C'wlth.Govt.Printer, Canberra.
- JARRETT, P.H., PETRIE, A.H.K. & PATTON, R.T. 1929.
 The vegetation of the Black Spur region.
 J.of Ecology 17: 2, 221-281.
- JENNINGS, I.B. 1955. Geology of portion of the
 middle Derwent area. Proc.Roy.Soc.Tas.
89: 169-90.
- JONES, E.W. 1956. Ecological studies on the rain-
 forest, Southern Nigeria. J.of Ecology
44: 1, 83-117.
- KITCHENER, D.T. 1958. Personal communication.
- LINDSAY, A.D. 1932. The western forests of the
 United States of America. C'wlth For.
 Bureau Bull. No.9.
- McLUCKIE, J. & PETRIE, A.H.K. 1927. An ecological
 study of the flora of Mt. Wilson. Pt. IV.
 Habitat factors and plant responses.
 Proc.Linn.Soc.NSW. 52: 2, 161-184.
- MARTIN, D. 1939. The vegetation of Mount Wellington
 and a census of the plants. Pap.Proc.Roy.Soc.
 Tas. 97-124.
 — 1956. Personal communication.
- METEOROLOGICAL BRANCH, C'WLTH. OF AUST. Book of
 Normals - No.1 Rainfall (1911-1940).
 — Departmental Reports.
- MORRISON, C.G.T., HOYLE, A.C. & HOPE-SIMPSON, J.F.
 1948. Tropical soil-vegetation catenas and
 mosaics. J.of Ecology 36: 1, 1-84.
- NICOLIS, K.D. 1958. Personal communication.

- PATTON, R.T. 1930. The factors controlling the distribution of trees in Victoria. *Proc. Roy.Soc.Vic.* 42: 2, 154-210.
- 1933. Ecological studies in Victoria Pt.II. The fern gully. *Proc.Roy.Soc. Vic.* 46: 1, 117-129.
- 1955. Vegetation in Victoria; in *Introducing Victoria, Handbook for A.N.Z.A.A.S. Meeting 1955, Melbourne.*
- PIDGEON, I.M. 1938. The ecology of the central coastal area of New South Wales. *Proc.Linn.Soc. NSW.* 63: 1-2, 1-26.
- POOLE, A.L. 1950. Studies of the New Zealand Nothofagus species. *Trans.Roy.Soc.N.Z.* 78: 502-508.
- PRACY, L.T. & KEAN, R.I. 1949. The opossum in New Zealand. *Wildlife Branch Bull. No.1, N.Z. Dept. Int. Affairs.*
- PRYOR, L.D. 1955. Improved germination of some alpine eucalypts by stratification. *Aust.Forestry* 18: 2, 104-106.
- RICHARDS, P.W. 1952. *The tropical rainforest.* Cambridge Uni. Press.
- RIDE, W.D.L. 1957. Protemnodon parma Waterhouse and the classification of related wallabies (Protemnodon, Thylogale and Setonix). *Proc. Zool. Soc. Lond.* 128 Pt.3: 327-46.
- RODWAY, L. 1903. *The Tasmanian flora.* Govt. Printer, Hobart.
- SHIRLEY, H.L. 1943. Is tolerance the capacity to endure shade? *J.of Forestry* 41: 5.
- BUTTON, C.S. 1928. A sketch of the vegetation of the Cradle Mountain, Tasmania. *Proc.Roy.Soc. Tas.* 132-159.
- SWAIN, E.H.F. 1928. *The forest conditions of Queensland.* Govt.Printer, Brisbane.
- THOMAS, A.S. 1945. The vegetation of some hillsides in Uganda. *J.of Ecology* 33: 1, 10-43; 2, 153-172.

TREWARTHA, G.T. 1954. An introduction to climate.
3rd edition. McGraw Hill, New York.

WAKEFIELD, N.A. 1957. The Tasmanian representatives
of the Pteridophyta. Pap.Proc.Roy.Soc.Tas.
91: 157-162.

WEBB, L.J. 1956. Environmental studies in Australian
rainforests I - V Ph.D.Thesis. Uni. of
Queensland.

WILM, H.G. 1946. The design and analysis of methods
of sampling micro-climatic factors. J.Amer.
Stat.Assoc. 41: 221.

APPENDIX
LIST OF PLANTS

<i>Acacia dealbata</i>	Silver wattle
<i>melanoxydon</i>	Blackwood
<i>mucronata</i>	Native willow
<i>verniciflua</i>	Varnished wattle
<i>Agastachys odorata</i>	White waratah
<i>Anodopetalum biglandulosum</i>	Horizontal
<i>Anopterus glandulosus</i>	Native laurel
<i>Aristotelia peduncularis</i>	Heart berry
<i>Astroloma humifusum</i>	Cranberry
<i>Athrotaxis cupressoides</i>	Pencil pine
<i>Auracaria cunninghamii</i> Ait	Hoop pine
<i>Banksia marginata</i>	Honey-suckle
<i>Bauera rubiodes</i>	Bauera
<i>Blechnum procerum</i>	Leech fern
<i>Cenarrhenes nitida</i>	Port Arthur plum
<i>Ceratopetalum apetalum</i> D. Don	Coachwood
<i>Cirsium vulgare</i> (Savi) Ten.	Spear thistle
<i>Clematis aristata</i>	Clematis
<i>Coprosma billardieri</i>	Native currant
<i>Dicksonia antarctica</i>	Man-fern
<i>Diselma archeri</i>	
<i>Drimys lanceolata</i>	Pepper bush
<i>Endiandra sieberi</i> Nees	Corkwood
<i>Epilobium</i> sp.	Willow herb
<i>Erechthites prenanthoides</i> (Rodway's spelling)	Fireweed
<i>Eucalyptus</i> <i>coccifera</i>	Snow gum
<i>deglupta</i>	Kumurere
<i>fastigata</i>	Cut-tail
<i>globulus</i>	Blue gum
<i>gigantes</i>	Gum-topped
	stringy-bark
<i>grandis</i>	Flooded gum
<i>gunnii</i>	Cider gum

<i>Eucalyptus johnstoni</i>	Brown gum
<i>lindleyana</i>	Kayero
<i>microcorys</i>	Tallow-wood
<i>obliqua</i>	Stringy-bark
<i>ovata</i>	Black gum;
	Swamp gum (N.Tas.)
<i>pauciflora</i>	Weeping gum
<i>pilularis</i>	Blackbutt
<i>regnans</i>	Swamp gum;
	Stringy gum (N.Tas)
<i>saligna</i>	Sydney blue gum
<i>simmondsii</i>	Smithton peppermint
<i>subcrenulata</i>	Yellow gum
<i>urnigera</i>	Urn gum
<i>vicinialis</i>	White gum
<i>Eucryphia lucida</i>	Leatherwood
<i>Gahnia psittacorum</i>	Cutting grass
<i>Grammitis billardieri</i>	Finger fern
<i>Hakea microcarpa</i>	Needle bush
<i>Haloragis micrantha</i>	
<i>Histiopteris incisa</i>	Soft bracken
<i>Hypolepis rugosula</i> (<i>rugulosa</i>)	
<i>Leptospermum lanigerum</i>	Woolly tea-tree
<i>scoparium</i>	Manuka
<i>sericeum</i>	
<i>Lomatia fraseri</i> R.Br.	
<i>Lyonsia straminea</i>	
<i>Melaleuca squamea</i>	
<i>squarrosa</i>	
<i>Mesomelaena sphaerocephala</i>	Button grass
<i>Microsachrys tetragona</i>	Creeping pine
<i>Monotoca lineata</i>	
<i>Nothofagus cunninghami</i>	Myrtle, myrtle-
<i>moorei</i> Maiden	beech
	Negrohead beech
<i>Olearia argophylla</i>	Musk
<i>Oxalis corniculata</i>	

<i>Phebalium squameum</i>	Lancewood; Tallow-wood (N. Tas.)
<i>Pherosphaera hookeriana</i>	
<i>Phyllocladus aspleniifolius</i>	Celery-top pine
<i>Phymatodes diversifolium</i>	
<i>Pittosporum bicolor</i>	Tallow-wood; Cheesewood (N. Tas.)
<i>Poa caespitosa</i>	White grass; snowgrass
<i>Podocarpus spicatus</i> R.Br.	Matai
<i>Polystichum proliferum</i>	Cat-head fern
<i>Pomaderris apetala</i>	Native pear
<i>Prostanthera lasiantha</i>	Christmas bush
<i>Pseudotsuga taxifolia</i> (Poir) Brit.	Douglas fir
<i>Pteridium esculentum</i>	Bracken
<i>Senecio australis</i>	Fireweed
<i>Sprengelia incarnata</i>	
<i>Syncarpia subargentea</i> C.T.W.	Giant ironwood
<i>Tarrieta argyrodendron</i> Benth.	Booyong
<i>Tristania conferta</i> R.Br.	Brush box
<i>Urtica incisa</i>	Nettle
<i>Zieria arborescens</i>	Stink-wood